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MECHANICAL ENGINEERING

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An Account of The A.S.M.E. Annual Meeting New York, December 5-9, 1921

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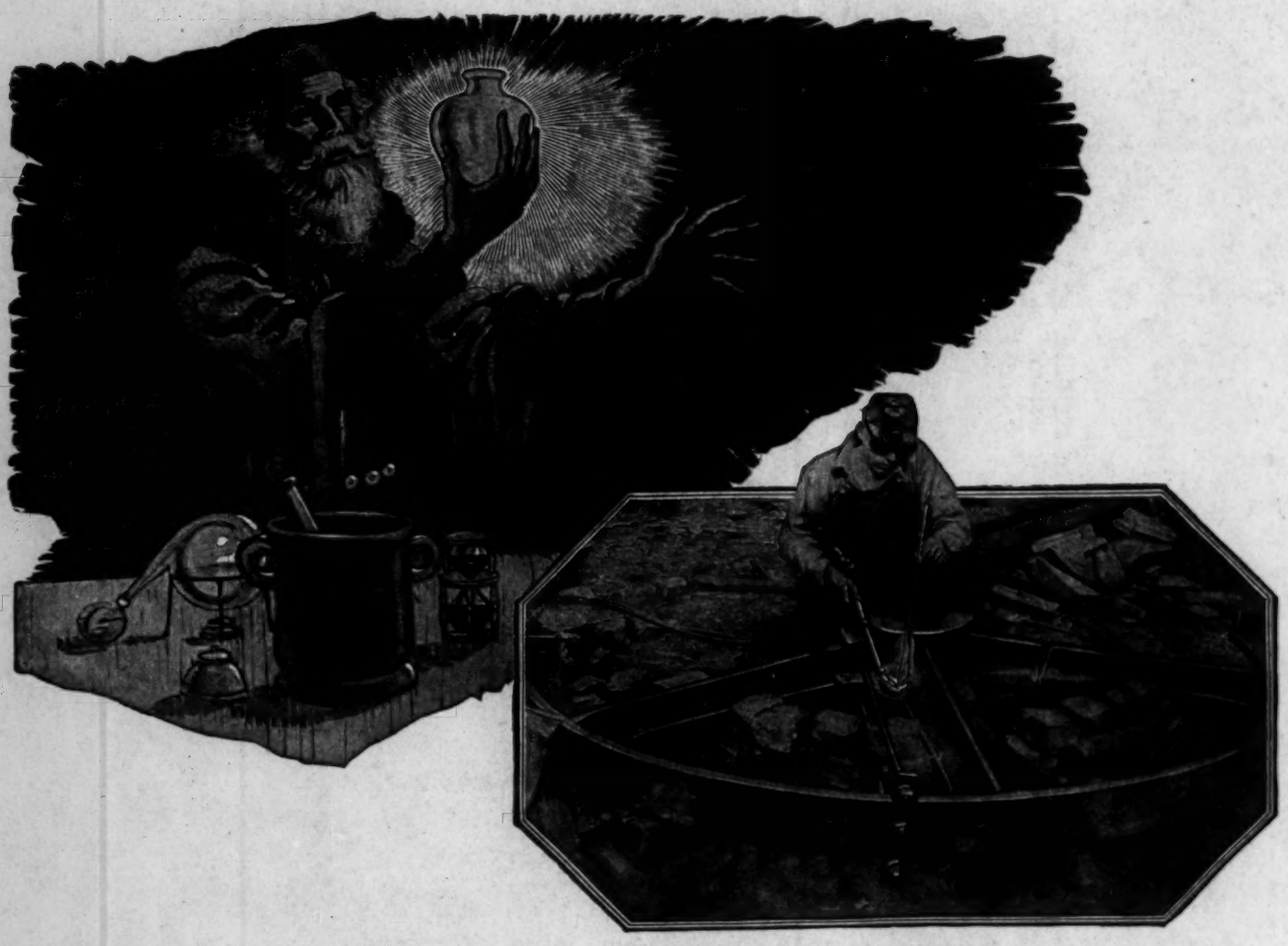
Process Charts and Their Place in Management, By F. B. and L. M. Gilbreth

JANUARY 1922

THE MONTHLY JOURNAL PUBLISHED BY THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS



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Volume 44 January, 1922 Number 1

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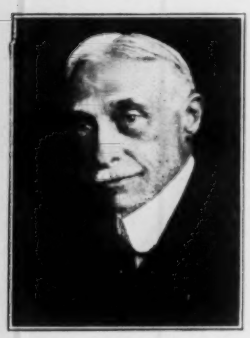
Contributors and Contributions

The Sperry Compound Diesel Engine



ELMER A. SPERRY

One of the interesting events of the recent A.S.M.E. Annual Meeting was the presentation by Dr. Elmer A. Sperry of a paper abstracted in this issue in which he outlined the steps taken in his solution of the problem of compounding the Diesel engine. Dr. Sperry, who has been at work on this problem for twenty years, is perhaps best known for his development of the gyroscopic compass, which has proved so successful. However, he has been engaged in many other activities since leaving Cornell in 1879. Among them might be mentioned the Standard Electric Company of Chicago, the Sperry Electric Railway Company of Cleveland, and others in the lighting and railway fields. During the recent war Dr. Sperry was a member of the Naval Consulting Board, which rendered notable service.

Professional Engineering Education

The A.S.M.E. Annual Meeting session with the Society for the Promotion of Engineering Education clearly demonstrated the importance of the problems involved in our engineering curricula and their relation to industry. The addresses and their discussion appear in this issue of MECHANICAL ENGINEERING.

Two of these papers present the needs of the industries. F. C. Pratt, a graduate of Sheffield Scientific School, was for several years connected with Pratt & Whitney Co., Hartford, Conn. He then became associated with the General Electric Company, of which he is now vice-president. He is also president of the Yale Engineering Association.

J. E. Otterson, president of the Wincheste Repeating Arms Company, New Haven, Conn., was graduated from the Naval Academy in 1904 and took a post-graduate course in naval architecture at Massachusetts Institute of Technology. He served as naval constructor in both the Boston and the New York Navy Yards.

A. G. Christie, professor of mechanical engineering at Johns Hopkins University and chairman of the Power Division, A.S.M.E., has had a broad experience in steam turbine work, both in this country and abroad. He has also taught mechanical engineering at Cornell University and steam engineering at the University of Wisconsin.

Steam Power Plant Heat Balance

C. Harold Berry and F. E. Moreton are co-authors of the heat balance paper in this issue. Mr. Berry is a 1912 graduate of Cornell University and served as instructor and assistant professor of heat power engineering at Cornell until 1918. Since 1919 he has served the Detroit Edison Company as research engineer and at present is engaged in technical administration work relating to design, operation and maintenance of steam power plants. Mr. Moreton is also connected with the Detroit Edison Company.

The Prevention of Waste in Industry

Major Fred J. Miller, with his long A.S.M.E. service record, needs no introduction to readers of MECHANICAL ENGINEERING. His address at the leading session of the recent A.S.M.E. Annual Meeting was inspired by his association with the work of the F.A.E.S. Committee on the Elimination of Waste and its contents are based on long experience in the management of industry.

Process Charts

An interesting method of pointing out weaknesses in methods of manufacture was presented by F. B. and L. M. Gilbreth at the Management Session of the A.S.M.E. Annual Meeting. Their paper is given in this issue. Although the name of Gilbreth is most closely associated with motion study, this remarkable couple has achieved much in other industrial applications of the science of management, notably in psychology and fatigue studies. Their present paper discloses the method used in analyzing the manufacturing processes of an industrial plant.

Commercial Flying

A new system of transportation can be founded only on facts derived from experience. In his Annual Meeting paper, abstracted in this issue, Major L. B. Lent has contributed some of these necessary facts of great importance to the developing of commercial aviation. Major Lent served with the Aviation Section of the Signal Corps, on active duty at the Curtiss Aeroplane Co., Buffalo, and later was commissioned Major in the Air Service and stationed with the 122d Aero Squad at Camp Alfred Vail, N. J. He is now president of the Lent Motor Fire Engineering Corporation, New York City. A further contribution to this important subject was made by R. B. C. Noorduyn at the Aeronautic Session of the Annual Meeting. His paper will be presented in the February issue.

Wireless Control of the "Iowa"

Rear-Admiral Robert S. Griffin (Retired U.S.N.), Hon. Mem.Am.Soc.M.E., has given an account in this issue of the detail of the wireless control of the *Iowa* when undergoing the recent bombing tests. An opinion has been advanced that the methods successfully used on the *Iowa* may be of future value for the remote control of steam power stations.

A.S.M.E. Issues New Publication

Part Two of MECHANICAL ENGINEERING has been superseded by A.S.M.E. NEWS, a semi-monthly publication for the membership of the A.S.M.E.

A.S.M.E. NEWS will increase the value of the Employment Service and will carry important items of the Society affairs. The first issue was published late in December, 1921.

MECHANICAL ENGINEERING

Volume 44 January, 1922 Number 1

S.P.E.E. Joins A.S.M.E. at Annual Meeting to Consider Engineering Education

A Group of Papers Presented at the A.S.M.E. Annual Meeting, in Which are Presented the Particular Needs of the Industries and the Problems that Confront the Engineering Faculties

ONE of the outstanding features of the 1921 Annual Meeting of The American Society of Mechanical Engineers was the joint session held on December 8 with the Society for the Promotion of Engineering Education, and devoted to a consideration of professional engineering education for the industries. Four papers were presented at this session, over which Prof. C. F. Scott, president of the S. P. E. E., presided, namely: Professional Engineering Education for the Industries, by F. C. Pratt; A National Policy on Engineering Education, by A. G. Christie; College Education as Related to Industry, by J. E. Otterson; and The Engineering School and the Industries, by Dexter S. Kimball, which latter partook of the nature of an introduction to the discussion of the preceding papers. The texts of these papers follow, together with a brief abstract of the discussions which they brought forth.

The session was opened by Professor Scott who presided: he said in part:

The industries constitute the organization through which engineering utilizes the forces and materials of nature and organizes and directs human activities for the benefit of man.

Today the national society of engineering and industry meets with the association of engineering educators; this is a conference between users and producers of human material for leadership in industry.

If producers and users of steel rails were in conference they would discuss the uses which rails are to serve, classifying the kinds of service, considering wherein past products had failed, inquiring as to chemical analysis and metallurgical treatment. They would seek improvement in production and discrimination in use. But the more difficult problem of the human material for technical and administrative leadership has received less attention.

It is easier to analyze steel than students; physical tests are definite—psychological tests are still indefinite; it is easier to specify materials than men; steel is inert and passive—men are alert and erratic.

But when, if ever, have these leading societies in engineering industry and engineering education met together for conference? Each society has been engrossed in its own activities for thirty or forty years. Now they are finding something in common. Users and producers are in conference. Let us try to agree on what we want and then determine how to get it and how to use it. How may boys of differing kinds be individually developed and fitted to varying needs and opportunities?

First, as to the schools. What are they teaching? The distribution of subjects in the four year courses (not including summer work) in mechanical engineering and administrative engineering at Yale is given in the following tabulation:

		Per cent	
		Mechanical	Administrative
General	History and English	13	13
Science	Chemistry, Physics and Mathematics	31	24
Engineering	Drawing, Materials, Mechanics, Power, Electrical Engineering	46	28
Administrative	Economics, Accounting, Management, etc.	8	21
Elective	Engineering, Administrative, etc.	2	14

Second, returning to industry. What is the quality basis of selection of graduates for an industry? Does industry want men familiar with current practice, or men grounded in general principles ready to acquire practical experience rapidly? Industry certainly does not expect any graduate to fill any position irrespective of natural ability, aptitude and preference, but what is the present practice in determining the qualities of the raw material and of adapting it to the needs?

If some men are needed for research and invention and a larger group for general engineering and production and sales and another for executive and administrative functions, are men for each kind of work carefully selected and specially trained? The inventor, the originator is rare. A dozen or a hundred men for general activities are easier found than a single expert or originator. Has not much of the dissatisfaction of the past product of the schools been due to a misunderstanding on the part of industry as to what the college graduate really is and inability to train him in industry and utilize him efficiently?

The technical school has been trying to bridge the old time gap between the formally classical and the rigidly scientific. In forty years it has made a marvelous advance. The goal of its early aims was to produce engineers of materials and forces. But there is a new demand for an engineering type of mind for the organization and direction of men. Can the same raw material and the same educational machinery and methods produce both products? What changes will meet the new situation? Are they simple or radical? These are the things we are here to discuss.

Professional Engineering Education for the Industries

By FRANCIS C. PRATT,[1] SCHENECTADY, N. Y.

DURING the year 1920 the General Electric Company, with which I have the honor to be associated, took into its employ 400 college graduates, of which number—

340 were graduates of electrical engineering courses
20 were graduates of mechanical engineering courses
30 were graduates of business or administrative courses
10 were graduates of miscellaneous courses.

Practically all of the electrical and mechanical engineering graduates entered into the student engineering courses covering a one-year period which have been most carefully planned at the several works of the company, while the graduates of the business or administrative courses became members of its accounting department, taking a two-year course in business administration, higher accountancy and commercial law. Fifteen graduates, including two who had specialized in physics and nine in chemistry, entered the research laboratories of the company.

The records indicate that over a term of years about one-half of the young men entering the student courses remain permanently in the employ of the company in the engineering, manufacturing, commercial or administrative departments of its general and district offices, or of its works.

[1] Vice-President, General Electric Company.

In entering into the daily work of a great industrial organization these young men come into contact with actual manufacturing and business conditions and acquire self-confidence and a practical experience which, in my opinion, the colleges cannot and should not seriously attempt to impart.

I regard it as an exceedingly healthy sign that there are so many inquiries being made as to our methods of technical education, but, at the same time, I want to say that the young men who, during the past few years, have entered the employ of the company with which I am associated, have, on the average, been better prepared mentally, physically, and morally than ever before. This is a very broad statement, but a most careful study of the conditions and the many inquiries made of our leading men who have the opportunity to come in close contact with these young men justify this conclusion.

During the past two years we have been engaged in reorganizing one of our most important designing engineering departments, largely increasing the scope of its work and its personnel. In recently looking over a report of the organization submitted by the engineer in charge, I was struck by the references to two young engineers, each of whom had been out of the company's student engineering course for a period of less than a full year. The report referred to one of these young men as proving to be a resourceful and inventive experimental genius along his particular line of work, and to the other as having perhaps the clearest understanding of the mathematics of this particular line of any one in the employ of the company.

The line of work is an exceedingly broad one, the engineer in charge is a particularly discerning man, and I think it a matter of great encouragement that talent of such character is being turned over to the industries by the educational institutions. It is true that the report, in referring to these two young engineers, referred likewise to four somewhat older and more experienced men who were reported as also doing particularly notable work in the department.

INCREASING DEMAND FOR TRAINED ENGINEERS

I have recently seen a statement that statistics show there has been a constant decrease in the number of engineers graduated from our American universities. The statistics were not cited in connection with this statement, but if, perchance, this statement holds true, the tendency would seem to be an unfortunate one, in view of the larger demand for engineering activities in our modern life, as partly reflected in the following statistics taken from the official records of Yale University:

Increase in all Yale graduates for years 1904 to 1916:

Law, medicine, ministry and teaching, combined	24 per cent
Manufacturing, finance and mercantile pursuits, combined	83 per cent
Engineering	160 per cent

I have also seen suggestions that the number of so-called cultural studies should be decreased and greater specialization made in the essential subjects of science, mathematics, the native language, and of commercial application of what is learned, and that the colleges should turn out young engineers whose services are of immediate value to the employer without several years of practical experience being necessary.

I have little sympathy with such points of view for many reasons, among which are the following:

While familiarity with apparatus obtained from laboratory work coincident with undergraduate studies is of great value in giving the students more appreciative knowledge of their subjects, as are also frequent visits to, and summer work in, industrial establishments during the undergraduate period, yet I am confident that nothing which the colleges can give can take the place of the practical experience gained in the atmosphere of an industrial organization, bringing with it an intimate knowledge of both methods and men with which and with whom one's life work is to be associated. In my opinion the time in college is so valuable that it should be primarily devoted to those things which can only be acquired later with a great deal of difficulty, the fundamentals necessary to all advanced study.

Earnest efforts are being made to combine the advantages of instruction in theory with those of practical experience by cooperative courses, carried on jointly by educational institutions and industries. A final opinion in regard to the effectiveness of these courses must, it seems to me, be held in suspense awaiting more extended experience with them.

TOO EARLY SPECIALIZATION RESULTS IN DISPROPORTIONATE NUMBER OF MEDIOCRE ABILITY

My observations also lead me to the conclusion that the percentage of those who fail to attain a reasonable degree of success is greater in the group of men of mediocre ability but narrowly specialized education than in almost any other group coming within my knowledge. Such men, unless extraordinary vigilance is exercised by those in charge, become permanently attached to an organization doing specialized work for which they have no particular adaptability, clogging the opportunities for younger, more able and progressive men to advance. It would have been far better for such a man if the head of department had, at the end of one or two years of employment, recognized the circumstances and frankly informed him that he was not likely to make a success in the professional work which he had undertaken, and advised him to enter into some other vocation.

If I were to make a broad criticism of our methods of engineering education as it exists today, I should base it upon too early specialization of the student, resulting in the turning out of a disproportionate number of men of the class to which I have just referred, i.e., those of mediocre ability and narrowly specialized education.

I should be disposed to strongly criticise another condition in our colleges which I recognize as an exceedingly difficult one to overcome, and that is, as the result of the high degree of standardization, induced perhaps by the numbers who have to be taught, the more brilliant men in the class are retarded in their progress by the requirement of a standard which can be met by the less capable students. If we are not only to attain, but also maintain, great eminence in the engineering professions in America, we should, and I think must, devise some means whereby the more promising students can with greater facility advance with breadth and thoroughness in their work.

It is, I think, significant that in the organization with which I am in daily contact, a noticeable number of our most accomplished theoretical engineers and research laboratorians have either pursued post-graduate studies at European universities, or else have had all of their scholastic training abroad. This may suggest an opportunity for American educational institutions which is not fully met at the present time. In this connection I think that the colleges should sternly resist the temptation to enter into specialized fields which are adequately covered by kindred institutions, and that better results would follow if, in general, each endeavored to maintain the strongest possible staff of teachers to give most thorough instruction in the fundamentals of the sciences, engineering, economics and languages, and confine its specialization to such work as it is preëminently fitted to carry out.

The industries need administrative men well versed in the sciences and in engineering, in order that they may lend appreciative and sympathetic support to the technical developments, which are, in fact, the very life blood of the industry and on which its future primarily depends. That the colleges of the country are alive to this need, is evidenced by the number of courses which have in recent years been established, teaching the fundamentals of the sciences, engineering, economics and languages, and variously referred to under the names of administrative engineering, commercial engineering, or other courses.

While it seems to me probable that a much larger proportion of the graduates of such general engineering courses will be utilized by the smaller manufacturers rather than by such highly specialized organizations as pertain to the electrical industry, yet I want at this point to put in a strong plea for the more thorough appreciation and use of technical graduates by all industries, both large and small. It is, of course, apparent that a college education is not in any sense the only road to industrial accomplishment, and, in fact, some of the ablest engineers and administrators of my acquaintance have secured the fundamental knowledge upon which their life's work has been based while persistently working in practical fields and without having the foundation of a college education. One frequently finds, however, in such cases, that the individual's development had been profoundly influenced by close association in his

work with a master mind, who, in reality, became a great teacher to him.

NEED OF THE INDUSTRIES FOR STRONG DESIGNING ENGINEERS

The industries need strong designing engineers thoroughly versed in the theory and practice of the art, who have such knowledge of material values and of men as to render their work effective. In general, the industries must look to the colleges for young men who have the knowledge, the enthusiasm for constructive work and the patient tenacity, which alone go to make up a successful designing engineer. In many respects the loss of a good designing engineer to an industry leaves a vacancy which is harder to fill than almost any other, as preeminence in design can only be attained through a happy combination of natural ability and of knowledge and experience gained by years of intelligent and exacting work. Owing to the highly developed state of the art there is undoubtedly a great deal of routine work to be done in designing engineering, which is not inspiring to young men, and experience indicates that a diminishing proportion of technical graduates is drawn toward this most important branch of work. While this must, I think, necessarily be one of the problems for the colleges, it is also one of very immediate concern to the industries, demanding the most resourceful consideration. In general, the goal of success in design work seems more remote to the young graduate than in other branches, and also the character of the work more exacting and confining. On the other hand, this fascinating field of investigation, research, and constructive accomplishment should appeal most strongly to one who has the imagination and courage to look well into the future, and the stamina necessary to accomplish a difficult task. I feel certain that far too many capable young graduates sacrifice their greatest ultimate development by yielding to the temptations of early rapid advancement along the easier lines, without sufficient thought of the future.

I wish only to add one thing more, and that is to point out the wonderful opportunities which modern industry offers in its research laboratories to specially talented and most highly educated technical graduates. The colleges must, I am sure, be most liberal in providing instruction and laboratory facilities for the growth of such picked students, and in inspiring them by the work and example of a few really great teachers.

SUMMARY

1 A careful study of a large number of college graduates employed at the several works of the General Electric Company indicates that our educational institutions are developing young men of real ability for the industry.

2 The suggestion that is sometimes made to reduce the amount of cultural studies in order to more intensively specialize on technical subjects, is not viewed with favor.

3 The time in college is of such value that it should be primarily devoted to those things which can only be acquired later with great difficulty. At best, the student cannot hope to attain in college the well-rounded knowledge and practical experience that are to be gained in an industrial organization.

4 A broad criticism of methods of engineering education is that it undertakes too early specialization of the student. Another is the lack of facility offered to the more capable students to rapidly advance.

5 Suggestions for modification and improvement of American educational methods may be gleaned from the fact that a noticeably large number of accomplished theoretical engineers and research laboratorians have either received all their education or pursued post-graduate courses at European universities.

Best results may be expected if each educational institution will strive to maintain a highly capable staff of teachers in the fundamentals of the sciences, engineering, economics and languages, and restrict specialization to only that work for which it may be preeminently qualified.

6 The teacher in engineering courses should constantly emphasize to those students who show special aptitude the great need among the industries for able designing engineers.

7 Through its research laboratories modern industry offers to specially talented and highly educated technical graduates wonderful opportunities for development.

A National Policy on Engineering Education

BY A. G. CHRISTIE,[1] BALTIMORE, MD.

IN one of the recent Aldred Lectures, Mr. Arthur West said among other things: "It is to my mind one of the greatest functions of the technical school to seek out from among its students those who have a natural aptitude for the profession and to help these men to the utmost if in addition to their technical abilities they show the character necessary to make such help worth while. I counsel the careful and painstaking education of the best students even at the expense of the mediocrities that exist in all student bodies. It should not be the duty of the faculty to nurse along the 'dubs' of the class to a precarious graduation. What modern civilization needs is not more engineers but better ones."

Dean F. L. Bishop is reported to have stated at a meeting in New York last spring that there is no first-class engineering school to be found in America. Dr. Comfort A. Adams supported this statement and guaranteed that he could prove in a five-minute oral examination that 98 to 99 per cent of the graduates in electrical engineering from any institution in the country did not understand in a thorough fashion the fundamentals of the subject.

One is led to conclude from the above remarks that the engineering world desires only first-class men, but that the engineering colleges of this country are unable to furnish such men. Since the late war this country has been the world's leading nation. If the United States would continue to hold this foremost position it must become a leader in the arts and manufactures, in culture and education, and particularly in engineering education, for our modern civilization depends to such a great extent upon the work of engineers. If it is true that we have no first-class engineering schools, it is time that earnest inquiry should be made to determine wherein we are lacking and what remedies should be immediately applied. This is a national matter, for national leadership in manufacture and commerce depends on engineering achievements. A national policy on engineering education is therefore a pressing need at the present moment.

[1] Professor of Mechanical Engineering, Johns Hopkins Uuiversity. Mem. Am.Soc.M.E.

WORK IN FOREIGN COLLEGES GENERALLY OF MORE ADVANCED CHARACTER

When discussing the requirements of a first-class engineering college, it is instructive to consider the leading engineering colleges abroad. Before the war some of the German technical schools were regarded very highly. Those at Charlottenburg, Dresden and Munich shared with the Zurich Polytechnic of Switzerland the reputation of being in the first class of continental engineering institutions. Foreign students, including Americans, were attracted to these schools in large numbers and this further increased their reputation. These colleges had first-class men on their staffs and in general instruction was of a high order. Particular emphasis was laid on fundamentals of engineering and on research. The German states were liberal in their financial support of such institutions and the professors were comparatively well paid and enjoyed a high social standing. These professors did a relatively small amount of teaching and devoted their time principally to research and to the leisurely study of their specialty, on which they generally wrote extensively.

Much of the actual experimental work in research in these foreign schools was done by graduate students and by paid assistants, of which latter there were sufficient numbers to readily carry on the work. The instructional staff did little clerical work and practically no student advisory work, as we know it in America. Therein lay the weakness of the German system. Great care was taken to impart exact technical and scientific knowledge to the students, but little thought was given to the development of char-

acter and personality. A recent speaker commenting on this fact stated that British and American engineers are frequently placed in executive charge of large enterprises, while continentally trained engineers are employed by them to do the designing and computing, character, resourcefulness and ability to handle men governing the selection.

A factor that has considerable influence on the courses offered in any technical college is the character and degree of advancement of the work done in the preparatory schools. In this particular the continental technical schools are particularly favored, for in general more advanced mathematics and physics, together with more cultural subjects, are taught in their preparatory schools than in American high schools. In fact, the equivalent of the first year's work and often a portion of the second year's work in American engineering colleges is required for entrance to the continental technical school. Consequently the work in these foreign colleges is in general of a more advanced character than here. Furthermore the students are older and more mature at entrance to such continental colleges.

An attempt is being made in Great Britain to build up a first-class engineering school at the Imperial Technical Institute, London. The war, however, prevented full development of these plans as soon as was hoped might be possible.

CONDITIONS IN AMERICAN COLLEGES

Let us now consider conditions in American engineering colleges. These vary from small, ill-equipped schools to institutions that should be considered among the world's best, both in equipment, ability of staff, and character of instruction. There still appears to be room for all these colleges, even though the character of training varies over a wide range. This is due to the fact that the technically trained man has many fields open to him after leaving college. The demand for men to fill subordinate positions in the industries will always take care of the less able men and those whose training has been inadequate. The more highly trained and more capable men advance to the foremost places in the profession, which generally lead to executive positions of a business character. An increasingly large number of engineering graduates have business and not technical positions as their sole objective. They take the engineering courses in college largely because they believe that the thorough analytical methods taught there and the training in the ability to "think straight" will be a considerable asset in business life. Engineering students may therefore be divided into three general classes: (1) Those of a truly scientific turn of mind who are capable of grasping and developing theories and of applying these to the analysis of engineering problems; (2) men of a practical nature, less capable or insufficiently trained to fall in the first class, yet very necessary for the subordinate positions in industry; and (3) those whose objective is pure business life. The great majority of students fall in the last two classes and this influences the character of college instruction to a marked degree. Practical laboratory and shop courses are stressed in many colleges and there is a steady demand for more and more instruction on the principles of organization and business economics.

The increasing popularity of the engineering courses has led to steadily increasing enrollments in nearly all colleges. Instructional staffs are overworked and underpaid. To care for this influx there seems to be a tendency to organize certain colleges on what would be called in factory organization a "quantity production" basis. Large numbers of students are handled according to definite fixed plans and personal contact is largely lost between instructor and student. A most unfortunate condition exists when an able and inspiring teacher is promoted to the head of a department and becomes so loaded down with administrative details that he does little or no teaching and loses the opportunity to exert his personal influence on students who should normally receive his instruction. The "quantity production" idea gives little or no opportunity for character building, which after all is the true basis for success in after life. Where students are handled in quantity the men automatically recite, work up laboratory reports, and pass examinations with very little opportunity for independent thought or action along technical lines.

Engineers in practice frequently criticize the engineering colleges very harshly for turning out graduates with seemingly inadequate training. Usually these critics have lost their proper perspective or have forgotten just how little they themselves knew of their specialty when they entered college and when they were graduated. They fail to fully appreciate the character of the boy as he enters college and with whom the teaching staff has to deal.

It has already been pointed out that the average student entering American engineering colleges is younger and less thoroughly prepared in fundamentals than the continental student. The American boy has several things in mind when he enters an engineering college: First and foremost, that the training will enable him to earn a better living than if he were without training and therefore he favors practical courses to pure theory; second, that athletics, fraternity life, and other college activities are almost if not actually of equal importance with instructional courses; and third, that his four years in college before entering a cold-blooded business world are going to be the happiest in his life and he must not fail to have a good time during his college career.

WHAT ENGINEERS DEMAND OF THE GRADUATE

Such in general are the motives and ideals of the undergraduate of the technical college. What do engineers demand of the graduate? In the opening paragraph Mr. Arthur West calls for better engineers by a process of selective education of only the most promising men. In what way must he be a better engineer? In the Report of the Carnegie Foundation for Engineering Education by C. R. Mann, it is pointed out that practising engineers stated the desirable qualities of an engineering graduate in the order of their importance as character, judgment, efficiency, understanding of men, knowledge and technique. Particular attention should be directed to the fact that technique, in which the continental graduate excels, is placed at the bottom of the list, while character holds first place. A recent survey by C. E. Magnusson[1] indicates that character is still considered of first importance but should be combined with a truly professional idea of service, and also that thorough training in fundamentals is more necessary than specialization.

Character building, tact, initiative, thoroughness, etc., can be developed best in the undergraduate by intimate contact with high-grade instructors, and by participation in college activities and athletics under more or less faculty supervision. This may be achieved in the smaller colleges, but unfortunately only a few have adequate laboratory equipment and can afford to secure the best men for their staff. "Quantity production" in larger colleges must be replaced by smaller groups of students and larger, less hard-worked, and better-paid staffs if the best results are to be secured. The adoption of a common code of ethics by all national engineering societies and the requirement that every graduate in engineering affirm this code would greatly increase the graduate's sense of responsibility to his profession and would certainly tend to elevate its ethical standards. Thoroughness and accuracy can be developed by problem work, and particularly by recitation courses. Personal contact of students with faculty is probably most highly developed under our American student advisory systems.

A limited student body has been characteristic of certain of our best medical schools. The Engineering Department of Johns Hopkins University since the war has deliberately attempted not only to elevate the standards of instruction, but to limit attendance among the upperclassmen to a small number of men. An attempt is thus made to retain the better men only of the first two years. This permits the most efficient use of facilities without overcrowding, and retains close personal contact between student and instructor. Furthermore, greater emphasis is laid on fundamental theory than on informational and special applied courses, leaving the latter for advanced study.

When due consideration is given to the age at entrance and to the preparatory training of our freshmen, it is obvious that one cannot expect a finished engineer at the end of a four years' course. The criticisms of the undergraduate work of our colleges by Dean Bishop and Doctor Adams seem therefore unfair.

Students in law and medicine are generally required to have a collegiate degree before taking up professional work. Such a requirement would unquestionably produce a better class of graduates if applied also to the engineering colleges. The profession as a

[1] *Journal A.I.E.E.*, September, 1921.

whole, and particularly employers of engineers, have, however, offered no special inducement to the colleges to develop such men. In fact, with the large number of graduates of the second and third classes mentioned above, it is doubtful whether the time and expense of such training can be justified or is needed.

GRADUATE WORK SHOULD BE CONCENTRATED IN CERTAIN SELECTIVE COLLEGES GIVEN STRONG FINANCIAL SUPPORT

What about the highly trained engineer and the research engineer comprising the first class? This is the class of men on whom America must depend for future leadership in engineering. These men form a relatively small proportion of the graduating classes. Their training, however, should be of broad character during the early part of their courses, though in regular undergraduate courses this selective education is seldom possible, and later they should be further developed along certain specialized lines. Such men would undoubtedly benefit by collegiate courses before taking up engineering training. It is not possible, however, to select from a group of applicants for admission to college the men who will later develop into the best engineers, and who are worthy of the most extensive training. Some plan must therefore be developed which will permit these specially gifted men to be given advanced training and to carry out research work. Many colleges have neither the money, facilities nor staff to offer adequate graduate work in all branches of engineering. It would therefore seem best to concentrate our graduate work in certain selected colleges which should receive the strong financial support of the industries and of the Government and the moral support of the profession at large. If scholarships to these graduate schools could be provided for the best undergraduates from all engineering colleges, well-developed technical men would be available to the industries who would equal if not surpass the continentally trained men. The requirements for admission at such graduate schools should be very rigid so that only the best men with adequate preparation could enter.

If the industries demand highly trained men from the colleges, they must be prepared to make such training worth while. When a request is made to an engineering school for a man, if a degree of Master of Engineering or Doctor of Engineering is demanded and if such men are given preference for positions and are paid somewhat higher salaries than the ordinary graduate, students will soon desire to get the advanced training. Graduate students in engineering will be few and of mediocre character as a rule until such an attitude prevails on the part of employers.

The new national policy on engineering education therefore requires greater financial support for the colleges, so that an adequate staff of high-grade men may be employed and personal contact with students secured through small classes. Greater emphasis must be given in instruction during the four-year undergraduate period to fundamental courses, leaving special professional training to graduate years. Certain colleges should be designated as graduate schools and adequate provision made for their proper support both by Government agencies, by private endowment, and by the industries. Scholarships should be provided by the state, by industries, or by the profession which will enable eligible undergraduates from all colleges to continue their work in the graduate schools. Finally, employers who desire highly trained technical and research engineers must give first consideration to the men with graduate degrees and must be prepared to reward them financially in proportion to their extra effort and greater expense in educating themselves.

The burden of maintaining America's supremacy in industry and commerce rests largely on the engineer. Let us therefore as engineers place before the American people this new national policy on engineering education so that our young men entering the profession may be the best fitted in the world to carry this burden and to advance still further the art and science of engineering.

Engineering Education as Viewed by the Industrialist

BY J. E. OTTERSON,[1] NEW HAVEN, CONN.

THE pedagogue is interested primarily in the process of education. The industrialist is interested primarily in its product. The student upon graduation, must pass from the supervision of the pedagogue to the critical survey of the industrialist.

It seems fair to assume that the purpose of education is something more than the mere acquisition of knowledge. The industrialist is obliged to look for something more. The student is likely to find upon graduation that those things which he has regarded as the purposes of the educational processes through which he has passed, now become only a means for the accomplishment of the real purposes of life. It is in developing this change of viewpoint that the student is likely to meet with disappointment, perhaps discouragement, and during this period the industrialist finds difficulty in adapting the student to his utilitarian purpose.

Knowledge is not of itself a qualification for large responsibility in industry. The encyclopedic type of mind which merely records impressions and facts brought before it may lack those qualities of imagination and initiative so essential to the accomplishment of practical things under adverse conditions, which do not always evidence strict conformity to the laws governing recognized and recorded knowledge. Something more is required than that type of mind which is merely a reservoir containing a large amount of knowledge in a static state. Modern industry is dynamic and moves at a tremendous pace. We want, therefore, the type of mind that will be immediately energized when the current is turned on; the motor type rather than the storage-battery, and when the individual progresses to larger responsibility he may be called upon to animate, magnetize and electrify other minds about him, and to develop the qualities of generation as well as those of motivity.

There are doubtless certain occupations in life where the possession of accumulated knowledge is both desirable and essential, but in industry this quality alone will not carry the applicant beyond the lower orders of subordination. He will take his place among those student clerical types that are the handbooks of industry; much thumbed and used and frequently showing signs of wear and tear and dilapidation; referred to for statement of facts or formulation of laws but in the emergencies of everyday life frequently passed by in the race for accomplishment. Such are not the positions in industry that are difficult to fill. The encyclopedic type is sufficiently common to meet the need and in the search for the type with initiative, vision, imagination and dynamic force, the industrialist must apply other methods than those of the school-room examination. The industrialist is concerned more with the effect of the educational processes upon the habits and character of the applicant than he is with the degree of learning which he has attained. The industrialist is interested in mental, physical and moral character rather than in pure intellectualism; more in the ability to acquire knowledge quickly through application and concentration than in the immediate possession of knowledge.

The habits of industry should have as their foundation the habits of the student who is preparing for industrial work. In passing from student life to industrial life he should be able to do so successfully by continuation of the habits he has acquired in his college training rather than by a radical change that places him in an unfamiliar environment of work and activity.

His college life should be something more than a mere signal drill. He needs the scrimmage and the actual game to develop his full qualities.

Some very practical industrialists hold the view that a college education is a handicap to business or industrial success and they point to the fact that something like 75 per cent of the responsible positions in industry are occupied by men who have not had the benefits of a college education but who have gone through the school of hard knocks; whose qualities are those of character, force, will power, initiative, industry, common sense and human

[1] President, Winchester Repeating Arms Co. Mem. Am.Soc.M.E.

understanding. It is indeed questionable whether within the limits of the training and experience of a college education these qualities can be developed with the same intensity and firmness as in the school of life that so closely links accomplishment with survival.

The college education most obviously and surely develops a larger capacity for social and cultured life but the social and cultural taste growing out of a higher education may prove distracting in a competitive field where complete concentration of a very practical kind is essential to success.

Without endeavoring at this point to place the responsibility, the college graduate who is an applicant for an industrial position all too frequently shows no knowledge of the work to be done in the field which he is about to enter. He evidences no particular desire, ambition or purpose and he has little knowledge of the direction in which he is going or desires to go. If an opening is offered him, he has no capacity of judgment as to his adaptability. He is generally quite willing to leave the question of his future work in life to the hurried determination of the industrialist, who in a ten-minute interview may attempt to analyze his character and assign him to a task in which all parties concerned hope that he may be successful. Obviously this is an uncertain and unscientific method of directing the human forces set free by college education.

Small wonder that so many find themselves in uncongenial employment, ending in discontent, perhaps discouragement, changing from one class of work and finally from one job to another without direction or control.

A force is defined by its magnitude and direction. I am not complaining as to the magnitude of this tremendous human force launched into the world with each graduating class, but I do regret the wasted energy that results from its lack of direction. Whose responsibility is it then to give it direction? Who is to sight the gun? Who is to lay it upon the target? Some such directing hand is necessary if we are not to be content with mere intellectual fireworks.

Development of Personal Talents

It is of course a question as to how far the college is expected to go in fitting men to take their places in a particular line of industry. In the ordinary four-year college course it is fair to assume that the college can do little more than lay the foundation for subsequent intensive training and development for a particular work. I am very definitely opposed to the shaping of educational processes toward training for a specialized type of work before there has been laid a foundation of general knowledge and comprehension. The specialization should come after a certain degree of intellectual maturity has been reached. I do feel, however, that at the same time the mind is being molded and stored with knowledge, an effort should be made to determine the talents and characteristics that must be the controlling factor in the student's later life, and an opportunity given for the development of those qualities that will ultimately express the real character of the individual.

Our college tests and examinations are primarily directed toward the determination of mental attainments as measured by the extent of acquired knowledge. I am making a plea for the development of tests of a different character calculated to determine the student's potentiality rather than his static state. These tests would be in the nature of or the basis of a psychoanalysis of the student's character through observation of his manner, personality, physiognomy, heredity, environment and college career. These should be matters of constant observation and record, with particular reference to progress and development. These observations and records should be the constant study of a skilled psychologist or psychoanalyst who would take occasion to periodically counsel with the student as to his predominant characteristics and talents, assisting and directing him to their higher development.

At a later point in the student's career, an organized effort should be made to acquaint him with the opportunities in the field which he is by character qualified to enter, his qualifications being determined not by the character of acquired knowledge that he possesses as defined by the usual academic classification, but rather by the qualities of mind and character that give direction to his energies.

It is not my purpose to attempt to define the organization or system by which this may be accomplished nor to attempt to detail the method of character analysis to be pursued. Presumably a broad general classification will be first attempted, to be followed by more detailed effort.

Types of Men in Industry

For example: Two distinct types are constantly being recognized in industry, namely, the engineering type and the executive type.

The engineering type of man works for the solution of a single technical or engineering problem and is concerned with the determination of the solution rather than the application of that solution to practical activities. The true type has the capacity to concentrate continuously on a single problem until the solution has been reached. He is interested in the determination of cause and effect and of the laws that govern phenomena. He is disposed to be logical, analytical, studious, synthetical and to have an investigating turn of mind. The predominating characteristic that distinguishes him from the executive is his ability to concentrate on one problem to the exclusion of others for a protracted period, to become absorbed in that problem and to free his mind of the cares of other problems. He does not submit readily to the routine performance of a given quantity of work. He deals with laws and abstract facts. He works from textbooks and original sources of information. Such men are Edison, Steinmetz, the Wright brothers, Curtiss, Bell, Pupin, Fessenden, Browning. These men are the extreme of the engineering type, they have enormous imagination, initiative, constructive powers.

The executive type takes the conclusions of the engineer and the laws developed by the engineer and applies them to the multitude of practical problems that come before him. His chief characteristic is that he works with a multitude of constantly changing problems at one time. He concentrates on one problem after another in rapid succession. In many instances he has not the time to obtain all of the facts and he must arrive at a conclusion or make a decision based upon partial knowledge. He must rapidly assimilate available facts and fill in what is lacking from the ripeness of his own experience, frequently calling upon his powers of judgment, and even intuition. He is a man of action, boldness, ingenuity, force, determination, aggressiveness, courage, decision; he is possessed with the desire to get things done, impatient of delay. He works from a handbook, a newspaper or nothing at all. Such men are Schwab, Goethals, Pershing, Farrell, Hindenburg, Hoover.

If we have accomplished nothing more than to assist the boy to determine whether he is a potential engineer or an executive, it seems to me that we have gone a long way.

The question of whether a man has been trained in mechanical engineering or electrical engineering is not half so important as whether he is a real engineer or a real executive. I am sure that we are all acquainted with hundreds of young men who have made their success in some other branch of engineering endeavor than that in which they received technical training, and I feel quite safe in saying that the qualities of character determine a man's success rather than the particular kind or extent of technical knowledge that he has received in his college course.

Perhaps at the same time that the suggestion is made for the amplification of college training so as to include the psychoanalytical treatment of the student, it would not be out of place to suggest that industry take up a similar work on its own account and for its own purposes, with a view to confirming or supplementing the determinations made in the course of college life. It seems obvious that there is a community of interest as between the student, the pedagogue and the industrialist, in that all are seeking the same end, namely, the development to the full capacity of the individual for accomplishment.

We seek only to avoid the wasted energies, the wasted years and the wasted lives; the discredit to educational institutions and the loss to industrial and national life. The limitation upon industrial accomplishment today is men and the industrialist is calling for your assistance in minimizing this limitation. We require men rather than students and intellectualists. Will you give thought to the direction of the human forces which you generate?

The Engineering School and the Industries[1]

By DEXTER S. KIMBALL,[2] ITHACA, N. Y.

ONE of the most remarkable developments in the last fifteen years, perhaps, has been the spread of the use of the word "engineering." The reason for its present extended use is no doubt because we lack some adequate term to employ in its place. What it means is, we are going to extend the methods of engineering to all human activity. First, we have applied it to industry. Now, we are going to apply it to management and then to finance, then to the human element, and lastly to religion. With all this has come also a clear recognition that there is such a thing as the engineering type of mind as contrasted with the legal or medical type. It is a distinct type of mind, one that employes a certain method of attacking problems.

Every graduate of a technical institution views the matter of education through spectacles of his own making. He has some criticism to make or some suggestion for his school's betterment, and many of these have been most useful. Every university faculty welcomes criticisms and suggestions, because they serve to enlighten them as to where they are going and as to what should be done with their curriculum.

In this country the average young man arrives at a university at the age of 17 or 18, and is usually graduated at about 22 or 23. It is not good to have boys stay in the university too long, for their vertebrae become stiff. In the four years allotted to the educator, he must take this young man and try to teach him mathematics and engineering subjects, train his character; he must further teach him English, of which he knows nothing. That, it should be noted, is a criticism on the lower grades of school. He must also teach him something of the classics, and lastly, must turn him out a finished engineer.

The list of things that must be instilled into these young men in four years is a long, long one, and if the faculty to which I have the honor to belong should undertake to incorporate in its curriculum the one hundredth or thousandth part of the suggestions they receive, nothing but chaos would result.

No man can properly be called an engineer who has not studied mathematics, physics and the mechanics of engineering. When it comes to the amount or quantities of these subjects, however, most men who have given much thought to this problem will probably agree that three years are sufficient to give a man a thorough grounding in these essentials of engineering training. This will leave a year in which the boys may be given some knowledge of the other fields about which they apparently ought to know something.

One of the first things that was brought to our attention as a requisite for the engineer was economics. That was not difficult to incorporate. Every engineer is by nature an economist. Every great power house is a problem in economics. The engineer studies economics quite willingly, and it has become a large part of the engineering curriculum.

The next demand—and an insistent one—was for a large amount of work in management, administration. We now have as a last demand this matter of human engineering. The engineer ought to know a great deal about the human element in industry, but generally speaking, he has not in the past been concerned with the human element. It has only been in recent years that he has been brought into touch with this problem; and, it may be said that he has been a little cold-blooded about it. He wants to get things done, and means are ways to an end.

If you are going to have the type of man that does things—and remember that engineers are the great ways and means committee of civilization—you may do other things, but you may not take away those fundamentals and get what I call the engineering type of mind. If I were to make any reply to the industrialist who adds that we do many of these things in the hope of getting men more closely adapted to their requirements, I would say that they, as a rule, have not appreciated either this problem or its solution. The industrial leader has seen fit to criticise the university without offering many constructive suggestions as to how the problem can be solved. One of our great industrial leaders some time ago remarked that if he had his way he would put industrial leaders at the head of all universities. His argument was that the universities are too far away from industry. Well, I hope that they may, in some respects, stay away from industry, and I hope there will always be in this great land universities where teachers are free to teach the truth as they see it. I am free to admit that one of the things that must be done is to give these young men some knowledge of the human problem and related problems, but I do hope there will never come a time when institutions will be adopted by industrialists, who have only in mind the peculiar problems of industry, and have not clearly in mind that the great hope of civilization lies in the engineer, and in making him as ideal as we possibly can.

ENGINEERING EDUCATION DISCUSSION

Dean A. A. Potter of Purdue University submitted a written discussion, in which among other things, he said that our curricula are in general designed to teach students basic subjects which they cannot acquire by their own efforts after they graduate from college.

Mr. Pratt had stated that the engineering schools undertake too early specialization. While the pressure from the outside was great for specialization, a study of the present curricula of engineering schools would reveal the fact that the tendency was to reduce specialization and to broaden the training of the undergraduate.

Carefully kept personnel and academic records should enable engineering educators to discover men who are of the inventive type and who can be developed into inventors, designers and research engineers. The inventive type of student usually shows his talents when very young and his training must be entirely different from that of men who are to enter the fields of production, sales or of public service.

A curriculum which provides no contact with engineering problems during the first two years is bound to discourage many of the more practical and ambitious students.

There is too much tendency in our entire educational system to encourage the development of "one text book" people and without basing the instruction upon the students' ability, aptitude, knowledge and experience. Apparently very little effort is being made to discover and to develop the student's talents.

Statements have been made that there is a distinct need for more highly trained engineers. He would like to have the opinions of Mr. Pratt and of others from industry as to whether we are justified in encouraging students to devote two more years to their preparation. To be more specific, what inducements could industry offer to our exceptional students if we encouraged them to spend five or six years at college instead of four?

M. W. Alexander[1] said that meetings like the one in session were highly desirable, but they would not bring results. It was necessary for the engineering professors and the industrialists in each community to come in close touch, so that the former might learn from the latter of the progress made in the art and the application of the science and of the adjustment that the engineering schools should make as rapidly as possible in order to catch up with the rapidly advancing industries.

A. M. Greene, Jr.,[2] speaking of the demands on the colleges for specialists, said that these were being met by training men whose fundamental work was of such a nature that it prepared them so that they were able to think, reason and apply. Personal contact was one of the most important parts of the work, but, with the increase in size of classes it was growing rather impossible. Some of the best work done in preparing men to go out and solve the

(*Continued on page 42*)

[1] Introduction to discussion of the preceding papers on engineering education. Slightly abridged.

[2] Dean, College of Engineering, Cornell University, President Am.Soc. M.E.

[1] National Industrial Conference Board, New York, N. Y. Mem. Am.Soc.M.E.

[2] Professor Mechanical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. Mem.Am.Soc.M.E.

President Carman's Address

ANNUAL MEETING, 1921, THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

A.S.M.E. Has Emerged From First Epoch Related Principally to Scientific Advancement of Material Things and Now Faces Second Epoch—the Problem of Human Relationships

BEFORE discussing the main theme of my address I desire to relate some of the principal Society activities of the past year. In the year 1920 the spirit of unrest that characterized the human mind as a result of the years of warfare was at its height, and gave expression in most walks of life. It was rampant in engineering society circles, and it is with great pleasure tonight that I give expression to my findings covering the operation of the affairs of our Society.

Our Society is democratic in organization, representative in government—its operation is coöperative—its activities extend into every part of the United States and are within reach of almost every member, and its accomplishments are contributions to the welfare of mankind.

As President I have traveled over twenty thousand miles. I have visited and addressed local sections and business organizations, carrying the message of engineering ability and its relation to the great economic problems of the day.

I have failed to find "politics," or any group of men, or any one man, governing the affairs of our Society.

The San Francisco man has as "much to say" as the New Yorker, and the West Coast members of Council and committees are as conspicuous as those from any other section; North and South, East and West, are united.

There is not anywhere apparent group or faction, friction or discord, except the friendly differences of opinion. We are all one large family, its members helping each other, all working for the upbuilding of our Society.

One year ago The American Society of Mechanical Engineers celebrated its fortieth anniversary. The Local Sections in forty cities held meetings, and with glad hearts told of the accomplishments of the past forty years.

FORTY years of Society activity, and
FORTY cities celebrating;
FORTY—a cardinal number with great significance. The "Fortieth" Anniversary is used many times to indicate completeness. Israel's greatest kings each reigned forty years, the ancient Venetian court was composed of forty.

Do these first forty years represent the first epoch in the history of our Society?

Has the epoch been completed? All indications point that way, and if it has, then we are now closing the first year of the *second* epoch. In the years ahead I believe there will come the realization that a year ago marked the distinct closing of the *first*, and beginning of the *second*, epoch.

The important accomplishments of the first epoch related principally to scientific advancement of material things. What is to be our aim for the second epoch?

The beginning of the first epoch was coincident with the beginning of a constantly and greatly increasing demand for mechanical equipment and allied engineering projects.

The American Society of Mechanical Engineers has been a splendid copartner in all the technical and scientific developments. It has rendered, and still is rendering, a valuable service to industry.

It was, at its beginning, organized to assist in the solution of the great problems of its day. These problems were technical and scientific in their nature, and their solution contributed to the rapid increase in quantity production, through the aid of mechanical appliances. So rapid and complete was the development that many operations were accomplished with little effort on the part of man. But in many instances the elimination of the effort produced an operation of drudgery—and drudgery always creates dissatisfaction and strife.

If we are to follow the policies of the founders of our Society, we, too, must assist in the solution of the greatest problems of our day.

You will agree with me, I am sure, that the greatest problem of today is neither technical nor scientific, as applied to material things. It is one of human relationships.

If the problem were only the relationship existing as man to man, then it would not be one to be considered by engineers. But our problem is more than one of man to man; it involves not only the relation of man to man, but also the relation of man to production—to intense and mechanical production—of man to waste of production and consumption, of man and his relationship to industry, and of industry and its relationship to man.

In the early developments, engineers as a whole gave attention, in machine design, or plans for large projects involving labor, to the producing of results, regardless of their effect on the person or persons engaged as operators or workmen.

Today it is and should be necessary to consider the human side of quantity production, and since this can best be done in connection with technical and scientific progress, it follows that the engineer, whether he so elects or not, must be the one to assume the responsibility, as the technical, scientific, material and human elements of progress must be considered collectively.

Our problem of today had its beginning in the introduction of machines and mechanical appliances to production; and with the introduction of the labor-saving devices there also began that kind of intense, nerve-racking, vitality-consuming labor that has been constantly continuing and increasing, until it has produced one of the greatest problems that has ever vexed mankind. This problem is commonly called "Industrial Relations."

It is true that the origin of labor trouble can be traced back through centuries, but those are not the labor problems that give expression in organized labor today.

Coincidently with the demand of civilization for great quantities of the articles of its consumption came the necessity for larger industries. As these industries became more numerous, many of them combined and formed large organizations for the purpose of self-protection, self-advantage, and control of markets.

Likewise the bringing together of many workmen, each with a certain and definite task to perform, gave opportunity for an interchange of grievances and a combined or group effort which has resulted in the labor organizations we have today.

Thus we had, growing side by side, two distinct organizations or classes: one, Industry or Capital, the other, Labor Unions or Labor. Not only have both of these organizations increased in size, but each has combined and federated with others of its kind, until both are unwieldy—overgrown, unable to control or direct their followers—each seeking the advantage over the other, and both actually taking advantage of the great consuming class, the Public.

We have still another complication, a third party—the Government—attempting to direct the other two, and the result is more deplorable than ever.

Since the Government is administered by a class which we in America call "politicians," and since each class has its own interests to protect, it follows that no one class should attempt to control the other two.

What, then, is the solution? After years of struggle, after countless endeavors from many different angles, the problem remains unsolved, and growing worse. There must be some method that will solve it.

The party most vitally interested, when rightly led, will be the deciding factor—*public interest is paramount.* What group of men is best fitted for leadership?

The great depression of today has seemingly lessened the apparent necessity for urgent consideration of the problem, but the problem is still with us, unsolved, and with the revival of business it will become more acute than ever.

I recognize in society today the existence of three laws: the

(*Continued on page 74*)

Prevention of Wastes in Industry

By FRED J. MILLER,[1] NEW YORK, N. Y.

THE Committee on Elimination of Waste in Industry devoted most of its attention to wastes of time and effort because these are far more important than wastes by direct loss of materials.

I think I need not discuss the grosser forms of industrial wastes that come from loss in various ways of supplies and materials. Such losses are relatively unimportant and means of preventing them are now very generally understood and are in use in practically all establishments in which it is realized that the safeguarding of such things that cost money is as important as the safeguarding of money itself.

I am asked to discuss, not simply wastes in industry, but incentives for the prevention of such wastes, and here we are confronted with the anomaly that those who would be supposed to have the greater incentive for the prevention of industrial wastes are found to be responsible for the major portion of the wastes that occur. Responsible, I mean, in the sense that they, the owners and directors of industries, are the ones and the only ones, who can adopt effective means to stop these wastes.

This seems to indicate that not only must there be incentives for the avoidance of waste, but there must be also a clear realization that preventable wastes are occurring and a general understanding of the reasons for them and of the means by which they may be prevented.

It is natural for the normal man to be active in some way—either mentally or physically, or both. There is scarcely a greater punishment that can be inflicted upon him than complete, enforced idleness, such as results from solitary confinement in a dark cell.

It is perhaps industry's chief problem to conserve, develop and make use of the natural desire of the normal individual to be accomplishing something, and, further, to relieve workers so far as possible from such conditions of work as are deadening to ambition, to initiative and to the creative instinct. Far more can be done along that line than may seem possible at first sight, and the results of even the simplest efforts in that direction have, in many cases, been very excellent for all concerned.

In a recently published magazine article the difference was clearly shown between having a foreman tell a group of workers that they must work overtime and, on the other hand, allowing the workers themselves to pass to each other and read a letter from a customer saying that unless his order was shipped by a certain date he would consider himself at liberty to cancel it. The workers themselves decided to work overtime to prevent cancellation of the order. And in all such cases the more ambitious workers can exert an influence upon the others far more effective than any other that can be brought to bear upon them.

Incentives in Industry Defined

Incentives may be grouped in two general classes which may be called the "penalty" class and the "reward" class.

The penalty incentives, in the form of the lash or other gross physical punishments, were more common in slave times than they are now, but the penalty incentive still persists here and there in various forms and there are still too many in our industries who seem to recognize no other kind; not knowing it is still true that "he who owns a slave is himself in chains."

Incentives of the penalty class make people afraid not to do the things they are ordered to do. Incentives of the reward class tend to make people want to do the things that are expected of them. These two classes of incentives of course differ widely in their nature; but they differ no more than the results that are obtained by them.

I do not know what course the discussion of this question may take here today, but I prefer to confine myself to discussion of the reward class of incentives as being the only one worthy of consideration in connection with industries carried on in an enlightened age and in dealing with free men.

The reward class of incentives may be divided into two subclasses that may be called respectively "group" rewards and "individual" rewards.

Profit sharing, group insurance, employee representation or participation in management, most of the so-called welfare work, general or so-called horizontal increases in wages, bonuses paid to all employees alike, etc., are and are intended to be group incentives; while individual increase of wages, piece work, bonuses to individuals for specific individual attainments are, of course, individual incentives.

Whether group or individual incentives should be employed in a given case depends of course upon the circumstances of that case; but my own experience and observation lead me to the belief that, after we have established good working conditions, such as well-lighted, heated and ventilated work places; done what we can to keep them in good sanitary condition and as free as possible from danger of accidents; and have foremen and other executives who have been selected and trained to take an enlightened and "human" attitude toward employees, the rest of the way to the best possible general results is through individual reward incentives; which may take the form of higher hourly wages paid to individuals for individual attainments, a bonus paid for definite attainment, advancement from the ranks to successively higher executive positions, or all of these together with, so far as I have been able to perceive, about equally good results when applied intelligently. And they can be applied intelligently only when means are provided for having a continuous record of every employee's performance with reference to established standards; so that reward incentives will not be based upon any executive's prejudices or whims but upon actual and demonstrated service rendered in doing the work for which the plant is operated.

As a consequence of the acute situation and the very troublous times we have been, and still are, passing through, there has been, I think, some tendency to overelaboration in certain of the measures taken to overcome our industrial difficulties. As for me, I still have faith in the comparatively simple means of enlisting the enthusiastic coöperation of minor executives and employees, and an essential part of this is to give them such treatment as every man likes to receive from those with whom he comes in contact; always remembering that workpeople are not, after all, essentially different from other people; are at least as readily responsive to candid, fair and courteous treatment as are other people, and also as well able to judge whether or not they are receiving it.

Causes of Industrial Wastes Itemized

And along with this there must be avoidance of the large industrial wastes that come from overloaded inventories; slow movement of materials through the successive operations of manufacturing; unskilled, because inadequately studied, and developed, manipulation of materials; inability to definitely and promptly place responsibility for delays; failure to clearly distinguish between those things which are the worker's responsibility, the foreman's responsibility, the superintendent's responsibility, and the owner's responsibility.

That all these, as well as the designing engineer, have their separate responsibilities is, in a general way, well recognized; but in our manufacturing establishments there is usually no means for definitely assigning responsibility in such manner that a record is made, clearly showing to all concerned where the responsibility lies and whose duty it is to take steps to correct the defect, assuming it to be remediable. Such a record does away with arguments and the attempts to shift blame from one to another, until finally it rests upon the man who cannot "talk back," or is canny enough not to do so and must bear it, smarting under the belief that he is unjustly blamed; and being disheartened and perhaps alienated by what he regards as being grossly unfair to him.

The major cause of waste in manufacturing lies in defective administrative methods, for which in general no one is to be seriously

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[1] Past-President Am.Soc.M.E.

Address delivered at the session on Elimination of Waste in Industry of the Annual Meeting, December, 1921, of The American Society of Mechanical Engineers.

blamed, for they are the methods that have the sanction of long usage and by them, or rather in spite of them, many successful enterprises have been, and are being, conducted.

Certainly owners and managers are not to be blamed in the moral sense for following well-established methods and practices, and of course they should follow them until they become convinced that there are better methods and practices that are open to them. On the one hand we see employers who are too easily prevailed upon by charlatans to take up methods that are little better than a group of unrelated "stunts," and on the other hand those who always delay progress along new lines until pretty nearly every one else is far in advance of them.

It is the work of engineers to educate and to show the better ways, and I predict that as time goes on our industries will be more and more directed by engineers who know how to direct them for production and who will regard production and service as the prime objects to be attained by an industrial organization. When this change has been effected, one of the greatest causes of waste will have been removed.

I could mention entire industries that are in the control of men who are little if at all interested in production, but devote their entire attention to high finance, which is often crooked finance.

HUMAN ELEMENT MUST BE RECOGNIZED

All signs point to new conditions under which our industries must be conducted. Improved methods of administration may go very far, but however, along with them, and an essential part of them, if we are to attain the highest immediate success and prepare for still further progress in the future, must be full recognition of the transcendent importance of the human element in our industries, and means simply must be found to remedy and avoid the condition into which so many of our industries have fallen and in which the attitude of employers and employees toward each other ranges from indifference or suspicion to more or less open and avowed hostility and a keen desire for revenge of wrongs, real or imaginary.

Ambitious men must be expected to have ambition for the welfare of their families, and from the social, political and industrial standpoints this is desirable and indeed necessary if our industries are to thrive by rendering service to society.

Foremen must be looked upon and must regard themselves as leaders, inspirers and teachers of their men rather than mere drivers; means must be provided by which the value of workers with respect to a fair standard can be indubitably ascertained and each should be unfailingly rewarded in proportion to his attainments.

Numerous examples, some from my own experience, might be given of the successful working of these principles, but as an illustration of what I mean, I prefer to go back to an incident related by Frederick W. Taylor, mainly because it is exceedingly plain and simple and also exceedingly enlightening to those who will study its full significance.

You will remember that at Bethlehem, Taylor, by patient, careful and really scientific study determined the best type of men, tools and methods for unloading ore from railroad cars. As results, the men were paid considerably higher wages than before, the cost of unloading cars was materially reduced, the men were not worked too hard for their physical well being, and all concerned were satisfied.

An establishment located elsewhere learned of this and hired some of these trained men, Taylor consenting to their going and at the same time telling them he would be glad to have them return if, for any reason, they were not satisfied in their new place.

The men went to work there, working as they had been trained to work, but found they could make no showing because they were only a few working with many others; their contribution to the total work done being therefore relatively small and indistinguishable from the work of the group. In other words, they could make no showing of their abilities.

They asked that they be assigned to definite cars which they could unload by themselves—as they had been accustomed to do at Bethlehem—and were brusquely told to mind their own business and work as directed.

They quit and went back to Bethlehem, and thus the effort to transplant the methods so carefully developed there failed.

And it failed simply because the human nature of these ore shovelers had been ignored; the management did not do its part by establishing the conditions that had been found necessary to success. It was a clear example of the old idea that industrial efficiency is to be secured by simply hiring the best workers available at as low a wage as they feel compelled to accept and then driving them as hard as possible. There may have been also a thought of the pace-making game which has been so much employed and which is still believed in by some employers, though it is extremely crude and the workers have very generally taken such measures as they can to protect themselves against it.

It must be recognized that even in the simplest work pride of achievement can usually be developed, and that often men will work their best only when they are not hampered by conditions that limit their achievements or that prevent them from being credited with their achievements; especially when they know, or believe, that these hampering conditions can be removed.

It would, I think, surprise a great many of us if we could know just how much of the wastes of industry that are caused by careless, inefficient work have a deeper underlying cause in a feeling created by the conditions under which men work, that make them believe they cannot do what they should do, and for reasons entirely beyond their control.

In a certain government establishment to which many good workers came during the war, mainly for patriotic reasons, quite a number of these men quit because conditions there were such that they could not do a fair day's work, no matter how much they might try. They did as much as was customary there, but so much less than they had been accustomed to do that they became disgusted and could not bear to remain.

It is by no means always easy to say where the blame lies for industrial wastes that come from slackness of workers and executives.

Take the case of a machine shop in which it is apparent that not much more than half the work is turned out that should be done. In many such cases the work has been brought up to the full standard by a change in the management, with or without a change in staff personnel, but employing the same workers as before.

BETTER MANAGEMENT OFTEN REDUCES WASTE

Too many there are who would, with all the assurance in the world, blame the previous inefficiency entirely upon the employees, but the hard fact that such inefficient establishments have been in many cases vastly improved by change of management or of management methods must be squarely faced if we are to comprehend our problems or succeed in materially improving conditions.

Especially do we need to adopt such methods of management as will enable the facts to be fairly presented to both sides in every difference that arises between employer and employee; and experience shows that when we have done that, both the employer and the employee are far more reasonable and considerate than either usually imagines the other to be.

It is at least as important that all the elements of an industrial organization should work together harmoniously and without friction as that the different parts of a finely designed and constructed machine should do so. When either does not function properly, it is a case for the use of intelligent discrimination in finding out the real cause of the trouble and the proper remedy. Usually the bludgeon treatment only makes things worse, no matter which side resorts to it.

Production has been and is restricted by workers, both organized and unorganized, and most of such restriction is of course wrong, from the economic standpoint, if not ethically.

In most industries, however, I think it can easily be shown that restriction of production by workers is insignificant compared with the restrictions caused by financial juggling of one kind or another; by avoidable irregularity of employment of labor and of plant by presidents or managers who are temperamentally unable to make decisions and then stick to them, or are unable to do so because they are under the control of men "higher up" who know nothing of industrial science, or even that there is any such thing; by unnecessarily large inventories and consequent tying up of capital that could be otherwise usefully employed; by inadequate con-

(Continued on page 42)

Forty-Second Annual Meeting of the A.S.M.E.

Sessions Held Under Auspices of Professional Divisions Consider Elimination of Waste in Industry—Honorary Membership Conferred Upon Past-President Henry R. Towne

FIVE solid days of professional and technical features characterized the Forty-second Annual Meeting of The American Society of Mechanical Engineers, and in this respect the meeting was far greater than any yet held by the Society. Not to speak of the social and entertainment features, into these five days were crowded over a hundred professional events. The social events were dovetailed in quite satisfactorily, and though the program was so very full, a well-arranged schedule insured the comfort of all members and guests throughout the week, with the result that there was unanimous agreement that the meeting was a great success. The thanks of the entire membership are extended to all committee members who contributed in any way to this result.

Notwithstanding the general situation in the engineering industries and the surtax on transportation—the two factors still operating to flatten the attendance curve—the registration was 1854, which compares very favorably with that of previous years. As it was, the facilities of the building were utilized to the full, the auditorium and the meeting rooms on the fifth floor, as well as the "best parlors" of the other societies in the building being in use all the time.

With one set of professional sessions on Monday and Tuesday and another set on Thursday and Friday, and with an all-day Business Meeting in between, there were virtually two "peaks" in the week, and most members from out of town welcomed the opportunity thus afforded to take care of their business and other affairs.

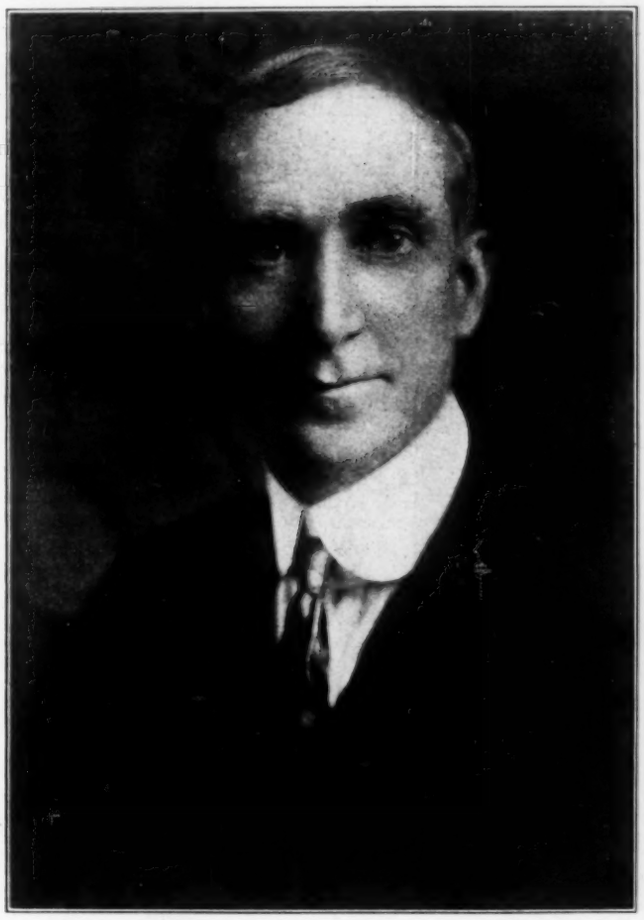
Of the nineteen professional sessions, nine were conducted by the new Professional Divisions, with the result that the technical information brought out was of a high standard.

The Annual Conference of Local Sections delegates was attended by representatives of 44 Local Sections. A more complete treatment of this meeting was given in the first number of the *A.S.M.E. News* issued late in December. It may be said here, however, that in addition to considering the organization problems of the Local Sections, a considerable amount of time was devoted to the proposed Constitution of the Society.

The entire day of the Business Meeting was given over to the new Constitution and two amendments to the present Constitution. The meeting voted to refer the amendments relating to the voting of Junior members and the mechanism of amending the constitution to the membership by letter ballot. The proposed Constitution was referred to the Constitution and By-Laws Committee for further revision and the discussion was carried through purely for the guidance of this committee.

At the Business Session the first award of the A. S. M. E. medal was made to Hjalmar G. Carlson for his invention and part in the production of 20,000,000 Mark III drawn steel booster casings used principally as a component of 75-mm. high-explosive shells, but also extensively in gas shells and bombs. The annual prizes for best papers were also presented at this session.

The meeting of the 1921 Council, with President Carman presiding, was held on Monday, and that of the 1922 Council, with President Kimball in the chair on Friday. The A. S. M. E. delegates to the American Engineering Council attended the Monday meeting and a large part of the time was given over to a discussion of the affairs of The Federated American Engineering Societies. On Monday the Council, the Local Sections delegates and the American Engineering Council representatives met at lunch.



DEXTER S. KIMBALL — PRESIDENT, 1922
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Twenty-seven committee meetings were scheduled on the program, and at least a dozen others were held impromptu. The Society flourishes in proportion to its committee work—the labors of the seven hundred-odd members who contribute their time and experience.

The leading social event was the Dinner-Dance at the Hotel Astor on Thursday evening. Four hundred participated in this delightful affair. The Smoker for the men this year was held at the Fifth Avenue Restaurant, and those who were fortunate enough to attend enjoyed songs, a few clever stunts and a first-class dinner. The President's Reception and the Ladies' Tea were equally enjoyable; they were held on the fifth floor of the Engineering Societies Building which was attractively decorated.

The formal excursions included visits to the Seaboard By-Product Coke Company, the Essex Street Station of the Public Service Corp. of N. J., The Davis-Bournonville Company, the Ford Motor Company, the oil-burning plant of the Singer Building and the S. S. *Olympic* of the White Star Line. The latter was the most popular for ladies as well as the members, and places in the party were at a premium. The steamship company provided tea, and the excursion was delightful as well as instructive.

An innovation this year was a graphic exhibit of the several activities and functions of the Society. This was arranged in the Society's rooms and attracted a great deal of attention and favorable comment.

The account of the Annual Meeting published here deals particularly with the business and professional features. Some of the papers have already been published, others are included in this issue, and the remainder will follow later.

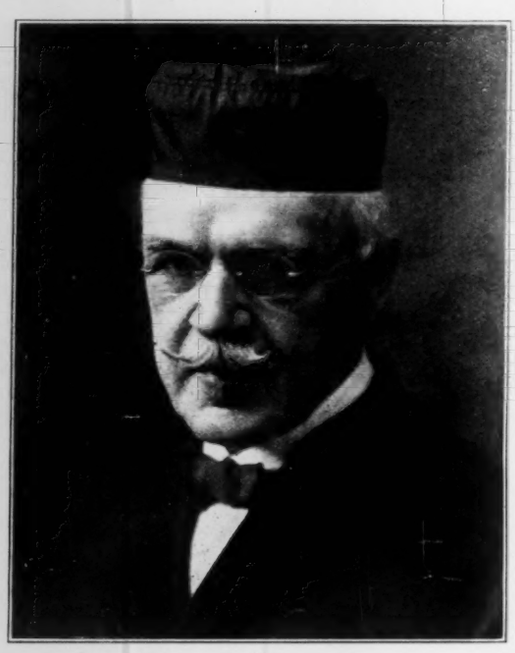
President's Address and Honorary Membership Award to Mr. Towne

ON TUESDAY evening of the Annual Meeting, after an inspiring address in which he portrayed the Society as having completed its first cycle and emerging into a new era, Mr. E. S. Carman relinquished the chair in favor of Dean Dexter S. Kimball, whom the membership had selected to head the Society during 1922.

President Carman's address is published in full in another column of this number.

The ceremony of introducing the new president was carried out after the chairman of the Tellers of Election, Dr. H. G. Tyler, had announced the result of the letter ballot of the membership, taken in the fall, to fill all the annual vacancies on the Council, as well as to elect the A.S.M.E. representatives for the year on the American Engineering Council, the governing body of the Federated American Engineering Societies. The names of all the successful candidates for office were read, and the announcement made that they had been elected by practically unanimous vote.

The new president was escorted to the platform by Past-Presidents Charles T. Main and Fred. J. Miller. In accepting the office, Dean Kimball said that the honor that had been bestowed on him held a peculiar significance, because one of his distinguished predecessors, Professor Sweet, was one of the first teachers at



Henry R. Towne

Cornell University, and another, his great predecessor in office at the University, Dr. R. H. Thurston, was the first president of the Society. With the honor, however, he acknowledged a great responsibility and pledged his very best effort to the members and to the Council in keeping the A.S.M.E. in the forefront as the highest representative of best engineering thought in the country.

Past-President Henry R. Towne Honored

A further ceremony of the evening was the bestowing of Honorary Membership in the Society on Past-President Henry R. Towne.

In making the award President Carman expressed great pleasure at the opportunity of reviewing the achievements and attainments of Mr. Towne, and his work for our Society since 1882, two years after its foundation.

Mr. Towne is a Life-Member. He was vice president from 1884 to 1886 and three years later served as president.

In early association with Robert Briggs he carried out numerous experiments in leather belting which were accepted as the standard for twenty years. He formed a partnership with Linus Yale in 1868 which resulted in the organization of the Yale & Towne Mfg. Co., which Mr. Towne directed as President until 1915, since then acting as Chairman of the Board. Mr. Yale having died in 1869, the responsibility and credit for the success of this firm is due largely to Mr. Towne, who greatly amplified original features and embodied with them radical departures in design and workmanship, especially in methods of production which have become accepted standards of the industry. During thirty-six years almost every improvement in locks or lock-making machinery came from the Yale & Towne Mfg. Co. Besides locks as such, Mr. Towne has become famous also as a manufacturer of complete post-office equipment, chain hoists and all manner of art hardware.

Mr. Towne's unusual combination of business and mechanical ability, his keen vision into the future and his untiring efforts to create and maintain a product and service of excellence, have made him the recognized principal factor in the growth and present high position of the lock art.

His contributions to technical literature and especially to the Society's publications have been numerous and basic.

Mr. Towne's Reply

In expressing his appreciation of the honor conferred on him, Mr. Towne recalled some of the early days in the Society, recording how it performed a function of usefulness especially to its younger members, as it does today. Then, as now, it trained its members in the habits of preparation for the meetings and of presenting their work so as to be of interest to others and, he hoped, to the community. In other words there has always been the thought of service. In this Society service belongs properly first to our fellow-members, then to the Society as a whole, the profession, and lastly to the community.

He thought that young men were apt not to realize this possibility of service in their work, and yet it underlies work of all kinds, and especially that of the engineer.

During the latter half of the long period of his membership his time and attention had been turned largely from purely engineering matters to those connected with the great city of New York, and sometimes to affairs of the nation. But in all these duties in which he had been able to render service, he had been aided by the fact that he had not only a technical training but also considerable experience in the practice of engineering and in the art of management. Therefore those of the younger men who have similar training and experience are particularly qualified to act as leaders in civic affairs, and he urged that without slighting their professional work they seek opportunities to engage in activities of this kind.

Reception of New Officers

Following the exercises in the Auditorium the company adjourned to the reception rooms where the new officers received the members of the Society and the ladies. Then came the customary informal get-together, with the renewal of old associations and the formation of many new ones. Music was provided, and the evening ended with an informal dance.

Opening Session on Waste in Industry

IN ANNOUNCING the general topic of the Annual Meeting of The American Society of Mechanical Engineers as Elimination of Waste in Industry, President Carman voiced the sentiment that in the years to come the deliberations of this convention would be looked upon as the inauguration of a practical program for waste elimination, not only in industry, but in all walks of life. It was traditional that the American people were wasteful, probably because of the great wealth of their resources, but he emphasized that the present was witnessing the inauguration of a program of economy which would redound to the credit of our nation.

Explaining that elimination of waste is largely a matter of management, the President said that the Management Division of the Society, now numbering upward of 1600 members, had contributed the program of this session, and he therefore introduced as presiding officer former chairman of the Division, Mr. L. P. Alford, vice-president of the Society.

Mr. Alford told of the interest, publicity and favorable comment that has been accorded to the report of the Committee on Elimination of Waste in Industry appointed by the American Engineering Council of The Federated American Engineering Societies. He felt, however, that if elimination of waste is to be put into practical effect in American industry, this must be done through

the individual acts of the engineers in the several professional societies.

Turning to the program, Mr. Alford then presented Past-President F. J. Miller, whom he also introduced as contributing to the Report by taking charge of the field investigations in the metal industries. Mr. Miller's message to the convention appears in another column.

PREVENTION OF WASTE OF POWER

In introducing the next speaker, Mr. Alford said that Major Miller had stressed the human waste in industry; Prof. L. P. Breckenridge[1] would present another point of view—the elimination of waste of power, to be made possible by a proposed consolidation of all sources of power in the country's great industrial zone from Boston to Washington.

Professor Breckenridge, speaking as chairman of the Advisory Committee of the Superpower Committee, described how emissaries from the Engineering Council had appeared before Government authorities and helped to secure an appropriation for a research or survey to determine what, if any, waste might be prevented by the development of what has come to be known as the Superpower System. The report of this survey,[2] made with the coöperation of 18 railroads, 558 public-utility companies, and the information reported through the census of 76,000 industries using power within the zone, is now available. The essential elements of the superpower plan are:

(*a*) Generation of power in plants of large capacity and high economy
(*b*) Locating those plants advantageously relative to coal, mines, condensing water, load centers and coal distribution
(*c*) Electric trunk lines in connection with the generating stations, both steam and water
(*d*) Unified system of control in charge of a power despatcher
(*e*) Delivery of primary power to electric public utility
(*f*) Local distribution of energy by the public utilities.

This latter includes the essential element of a superpower plant in this or any other zone.

Predicated upon curves extended into 1930, the expected economies are:

(*a*) Annual saving of 50,000,000 tons of coal
(*b*) Annual saving of $240,000,000
(*c*) Elimination of coke and its attendant wastes
(*d*) Elimination of waste of water power.

The other important effects will be:

(*a*) Material reduction in price of power
(*b*) Considerable transfer of coal transportation from land to water
(*c*) Increased flexibility of power distribution
(*d*) Opportunity for coal storage, tending to stabilize production
(*e*) Establishment of chemical, metallurgical, and other metal industries needing large power supply and high temperatures.

The superpower zone covers two per cent of the area of the United States, contains 32 per cent of the population, and manufactures 44 per cent of the products of the country.

The scheme of the superpower system is a large one, but it is the next logical step in the conservation of power resources. Following the survey of the facts will come studies of the local conditions under which the system can be installed, and finally the study of the financial conditions to take care of it.

[1] Professor Mechanical Engineering, S.S.S., Yale University. Mem. Am.Soc.M.E.

[2] Professional Paper No. 123, U. S. Geological Survey.

PREVENTION OF WASTE OF MONEY

The third speaker was E. F. DuBrul,[1] who directed attention to the tremendous wastes in industry caused by industrial depressions in business cycles. Within a century this country has passed through fourteen periods of depression of greater or less extent, but all involving serious loss to the investor in industrial enterprises.

Liabilities of concerns which failed in the past ten months of 1921 aggregated $591,000,000, but even this figure does not represent the wastes of investment, loss of useful values, loss of profits and wages in concerns which did not reach the bankruptcy court.

On all sides we are told that these losses are due to maladjustment of supply and demand, but this occurs because those responsible for supply know so little about the demand for their product that for considerable periods they purchase far more supplies than they need, and they waste capital in building plants to supply a non-existing demand.

If there are 9,000,000 automobiles in the country, each consuming four tires a year, or 36,000,000 tires in all, is it not waste of capital if 75,000,000 tires are manufactured for replacement?

This kind of error must be placed at the door of management, and can be avoided only by the coöperation of managers with each other in a study of the facts as to supply and demand of the commodities they produce.

However, the new economic conditions are compelling attention and business cycles are being studied as never before. Men are beginning to promulgate a fallacious gospel—that the end of business must be *service*, not production, not profit. Service is a means of gaining profit, and all business without profit dies—the controlling factor in management must be a financial factor—it stands the losses and it gets the profit where there is one.

In the last analysis, therefore, the controlling waste in industry is financial waste, and it seems not to be asking too much to ask management to eradicate this waste by recognizing its duty of adjustment of supply and demand.

DISCUSSION OF THE THREE PAPERS

The meeting was fortunate in having in attendance Mr. W. S. Murray, the Director-Engineer of the Superpower Survey, who supplemented the remarks of Professor Breckenridge by a visualization of the "point to be striven for" by the coöperation and coördination of all utilities within the zone, finally producing on the map such a system as some 500 engineers had agreed upon as a good mark for which to aim.

Mr. Murray was followed by Mr. H. W. Flood, secretary-engineer of the Survey, who demonstrated that the concentrated-power system, besides reducing fuel costs to about one-half, would also reduce labor, maintenance and supplies to about one third of those for independent operation as of 1919; accordingly, in discussing waste, it is important to add to the conservation of fuel, the saving of labor and capital.

Mr. J. Parke Channing, Chairman of the Committee on Elimi-

[1] Manager, Natl. Machine Tool Builders' Assn. Assoc-Mem.Am. Soc.M.E.

GROUP OF MEMBERS AND THEIR GUESTS ON BOARD THE S. S. OLYMPIC

nation of Waste, said that in stating that management is responsible for 50 per cent of the waste in industry, it is fair to say that all men who represent management are not engineers. In those industries in which engineers are prominent as managers and directors, there is and will be less waste than in those in which engineers do not fill their proper place.

Mr. W. N. Dickinson,[1] referring particularly to Major Miller's paper, said it was not brought out clearly that one of the incentives of industry is pride. Belief that industry is moving toward some worthy goal, and pride that his organization is a leader in that progress, will work as much in a man's mind as the promise of financial recompense.

Lewis F. Lyne, Jr.,[2] said that he had "boiled down" the *causes* of waste to negligence, lack of initiative, ignorance and poor service, and the *remedy* to replacement of management by people

SPEAKERS ON ELIMINATION OF WASTE AT LEADING SESSION OF A.S.M.E. ANNUAL MEETING

Left to right, back row: Ernest F. duBrul, L. P. Alford; front row: E. S. Carman, L. P. Breckenbridge, W. S. Murray, F. J. Miller.

who have the necessary ability to handle these inherent discrepancies.

George Vangelder[3] stressed the sociological side of waste. Is the problem the question of handling material and planning production, or should we use these things for the purpose of building up a better manhood in the country?

The incentive which made every worker in this country produce in the war is the incentive that the manufacturer must give his employee now—to produce, not for profit alone, but for building up industrial America.

R. A. Wentworth[4] combined the service and the profits motives of industry, disagreeing with Mr. DuBrul that the aim of industry is profit. This speaker referred to the work of the late Mr. Gantt, whose life was founded on the principle of service.

In his own experience he had never seen any deviation from the truth that sufficient knowledge of the problem, adequate observation of the facts and sufficient initiative in applying the remedy, could keep any business out of its trouble.

Mr. DuBrul, in his closure, challenged the discussion of his statement that the end of business was profit. He agreed that the means for profit was service, but that did not change the fact that the end of business was profit. There was never a business started for any other reason than profit.

Education and Training in the Industries

Monday evening was given over to a session dealing with the vitally important problem of education and training in the industries. The program was arranged by the Committee whose activities have been devoted to this subject under the chairmanship of W. W. Nichols.

An unusually interesting paper was presented by Dean R. L. Sackett, who outlined methods of education and training actually being used in industry in this country and abroad. The development of education and training in the railroad field was treated by D. C. Buell. These papers and the strong discussion incited thereby will appear in the February issue of MECHANICAL ENGINEERING.

[1] Consulting Analyst, New York, N. Y. Mem.Am.Soc.M.E.

[2] Pres. and Genl. Mgr., Oil Specialties & Supply Co., New York, N. Y. Assoc-Mem.Am.Soc.M.E.

[3] Sales Dept., Industrial Extension Inst., New York, N. Y., Mem. Am.Soc.M.E.

[4] Factory Mgr., American Everready Works, Long Island City, N. Y. Mem.Am.Soc.M.E.

Public Hearing on Proposed Code for Unfired Pressure Vessels

An important hearing was held on Monday, December 5, by the A.S.M.E. Boiler Code Committee to discuss a code for unfired pressure vessels, a preliminary draft of which has recently been issued. This pamphlet was the result of over two years of investigation and conferences with allied organizations.

The contributions of the Sub-Committee on Welding to this code are shown in the proposed specifications for autogenous welding, forge welding and brazing. While there was the attempt to render the code comprehensive, every detail of either the construction requirements or the various specifications on which there had been lack of agreement, was omitted. These points of possible disagreement were presented for discussion in a list of fourteen questions at the end of the report.

This preliminary report had been distributed in advance of the meeting to nearly 500 individuals and concerns known to be interested in the manufacture or use of unfired pressure vessels. The result was an attendance averaging nearly 200 during the entire day.

The preliminary draft of the proposed code was read paragraph by paragraph and discussion invited on each detail. The responses to the fourteen questions at the end of the report furnished the Committee with data valuable for use in shaping the code into final form. The Boiler Code Committee will give this data immediate and careful consideration so that the revised Code will be presented for further discussion, possibly in connection with the Spring Meeting of 1922.

Power Session

Four notable papers giving actual heat balance figures in three large public utility plants and the proposed scheme in a plant under construction were presented at the Power Session on Tuesday morning.

These papers presented valuable data that had not previously been made public and drew, therefore, a wealth of discussion. The three following papers appeared in the December issue:

AMONG THOSE WHO SPOKE AT THE POWER SESSION

Left to right, back row: Geo. A. Orrok, J. Anderson, O. F. Junggren, N. E. Funk, R. J. S. Pigott, Leo Loeb, F. R. Low, W. M. Keenan; front row: J. H. Lawrence, A. G. Christie, C. H. Berry, E. L. Hopping.

Auxiliary System and Heat Balance at the Delaware Station of the Philadelphia Electric Company, E. L. Hopping

Heat Balance of Colfax Station, C. W. E. Clarke

Heat Balance System for Hell Gate Station, J. H. Lawrence and W. M. Keenan

The final paper by D. H. Berry and F. E. Moreton giving the Heat Balance of the Connors Creek Plant of the Detroit Edison

Company appears in this issue of MECHANICAL ENGINEERING. This paper is followed by the discussion at the entire session.

MACHINE SHOP WASTE SESSION

AT THE Machine Shop Waste Session, held on the morning of December 6, F. O. Hoagland presiding, two papers were presented, namely: Salvaging Industrial Wastes, by J. A. Smith, and On the Art of Milling, by John Airey and Carl I. Oxford. In addition to these two papers, which were published in abstract form in the December issue of MECHANICAL ENGINEERING, an inspiring address on Waste in the Machine Industry was made by Mr. J. J. Callahan.[1] Mr. Callahan told of the benefits that had been derived in numerous instances by enlisting the interest of the workers in the problems of the management.

DISCUSSION ON SALVAGING INDUSTRIAL WASTES

Luther D. Burlingame[2] said that true salvaging might come by not having the scrap heap but by having parts so available that they were not to be had by merely picking in a pile. High-priced executives of shops or mechanics hunting for such things meant a waste of money. Another point was the importance of impressing on foremen, executives and others, the real value of salvaging materials.

A. L. De Leeuw[3] told of experiences with the Singer Manufacturing Co., where for a number of years several of his staff were constantly engaged in attempting to save some of the materials that were constantly being used in the shops, such as cotton waste, lubricating and cutting oils, belting, metal chips from machine tools, etc.

F. Eberhardt[4] discussed briefly waste prevention in machine castings. Carl G. Barth[5] gave examples of waste he had encountered in a large car works.

DISCUSSION ON THE ART OF MILLING

Professor Airey in presenting his paper called attention to some experiments made since this paper went to press, which related particularly to the consumption of power to cutters. The particular type of cutter compared is known as the right- and left-hand spiral cutter. It is an alternating spiral where successive teeth are formed on the opposite spiral. They had compared this type of cutter with one having all the teeth running in the same direction and found the alternate spiral to show a saving of between 20 and 30 per cent, depending on the material being cut. That represented considerable saving where a cutter consumed a lot of power. A cutter consuming 15 hp. in a nine-hour day would require 100 kw-hr. Effecting a saving of 20 per cent in the power required for that particular operation, would be a saving of 20 kw-hr., which at the Detroit rate of 3 cents per kw-hr., would be 60 cents per day on one small milling operation.

A. L. De Leeuw submitted an extended written discussion of the paper from which extracts follow:

It is to be regretted that the authors did not go a step further and attempted the separation of a chip by a very slow process, so as to enable them to observe the deformation of the metal at the different stages of separation, either by direct observation or by the moving-picture method.

The authors' determination of the direction, location and magnitude of forces in horizontal and vertical directions is somewhat along the line of Nicolson's experiments and, in the writer's opinion, deserves the same criticism. One of the chief requirements of machine-tool construction is rigidity, because it is well recognized that the lack of this rigidity increases certain of the forces or at least increases their effect on the work to an extent altogether out of proportion to the amount of lack of rigidity. Therefore, to place the work on movable pistons is to go away from the very essence of machine-tool design.

A milling chip tends to start with a zero thickness and, consequently, the cutter must slide over the work for some distance before it will be able to penetrate. The tooth, however, enters the work suddenly, so that, as a matter of fact, the chip as it is actually produced does not start with a thickness zero. Instead of having the theoretical shape as shown in Fig. 1, it will actually have the shape as cross-hatched in Fig. 2.

The observations about rake are closely in accord with the results the writer found in tests made between 1907 and 1914. The existing differences may be explained away by the fact that in his experiments part of the power consumed was used for feed.

Referring to the paragraph entitled, Effect of Clearance: Previous tests have shown the same result brought out by the authors namely, that clearance has no effect on the power consumption. However, it does have an effect on the life of the cutter and the finish produced. It seems that gritty materials require more clearance than those which will produce a continuous chip.

Early in the paper the authors state that as a chip thickens, metal is removed more easily per unit volume. As a practical rule, this statement is acceptable and meets all shop conditions.

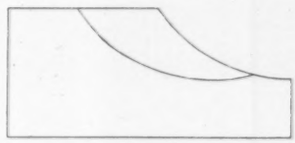


FIG.1.

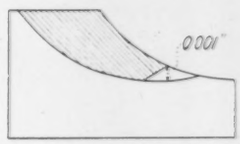


FIG.2.

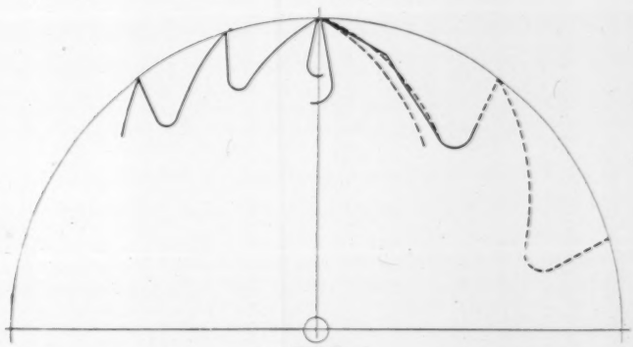


FIG.3.

FIG. 1 THEORETICAL SHAPE OF CHIP; FIG. 2 ACTUAL SHAPE OF CHIP; FIG. 3 RECOMMENDED PROPORTIONS OF TEETH

As a statement of accurate fact, it may be doubted. A number of observations made by the writer of this discussion showed that the efficiency increases when the cross-section of the chip approaches more and more a perfect square.

The writer must take issue with the statement contained in Par. 50 and following paragraphs. If the only point for consideration were the power required to remove a cubic inch of metal, the conclusions reached by the authors of the paper would be quite correct. However, in practice this power consumption was only one of the elements to be considered and not necessarily the most important one.

In a large portion of all milling work, one cut only is taken which is required to produce a finish of sufficient fineness. This finish depends on the number of revolution marks per inch. As a matter of fact, in a large percentage of all cases, the feed per revolution is limited by the desired finish at least as much as by the ability of cutter or machine to take the cut. The authors of the paper seem to be under the impression that the underlying idea for the introduction of the wide-spaced cutter was to supply sufficient chip space. As a matter of fact, this consideration only explains their origin. It was the observation of a case of insufficient chip space which induced the writer to try a somewhat wider spacing. Subsequent tests with these wider spaced cutters brought out further advantages.

In selecting the proper kind of cutter for a milling job, the following line of reasoning may be considered typical for a majority of cases:

The nature of the work compels us to limit the distance between revolution marks to, let us say, 0.050 in. In order to do the job as quickly as possible we must have as much feed per minute as

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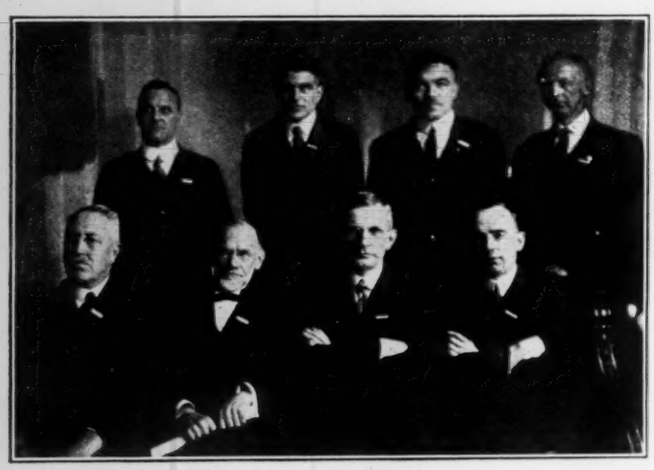
[3] Consulting Engineer, New York, N. Y. Mem.Am.Soc.M.E.
[4] Newark, N. J. Mem.Am.Soc.M.E.
[5] Philadelphia, Pa. Life Mem.Am.Soc.M.E.

possible. The feed per minute depends on two elements: cutting speed, and size of cutter. With the material to be cut and considering the depth of cut, we will be limited to a cutting speed of, let us say, 70 ft. per min. We must now select the smallest possible cutter which will do the work in order to get the greatest possible number of revolutions which will give 70 ft. cutting speed. Now enter such considerations as size of arbor, depth of teeth, size of keyway—all of which may prevent us from making the cutter as small as we would like to have it. If, for instance, we are compelled to use a fairly long arbor, we must make that arbor of sufficient size to avoid excessive bending and torsion. Having considered all these items we finally decide on the size of cutter. As we want to do the job with as little power consumption as possible, we must provide for taking the heaviest possible chips, and this in its turn means the smallest possible number of teeth in the cutter. It will be noticed that this line of reasoning is almost diametrically opposed to that followed by the authors of the paper. There are certain limiting conditions which prevent us from making the number of teeth as small as might be desirable. To have too great an angle between two adjacent teeth would mean that in practically no kind of cut would we have more than one tooth buried in the metal. To avoid the resulting hammer blow, we must put a sufficient number of teeth in the cutter.



SOME OF THE PARTICIPANTS IN THE MACHINE SHOP SESSION

Left to right, back row: F. K. Hendrickson, H. S. Beal, C. J. Oxford, H. J. Eberhardt; front row: H. P. Fairfield, Carl G. Barth, F. O. Hoagland, John Airey.

The original reason for the reduction of the number of teeth of a cutter was chip space. Soon afterward it was found that the power consumption was smaller and that, as a result, a given-size milling machine was capable of taking heavier roughing cuts with the wide-spaced cutter than with the older type. Other advantages showed up later on. Among these advantages are the fact that under many conditions a wide-spaced cutter will finish more pieces before it becomes necessary to resharpen it.

Not only does a wide-spaced cutter require less sharpenings, but it will stand many more sharpenings. Furthermore, it requires less time to sharpen a cutter with few teeth than one with many. It should be understood, however, that Mr. De Leeuw does not recommend the widest possible spacing for all imaginable cases of milling.

Besides the reasons mentioned, there are other reasons which may prevent us from taking the heaviest possible chips. In many cases it is not possible to clamp the work down in a sufficiently rigid manner to withstand the pressures accompanying heavy chips. In other cases, the piece of work may be of such a character as not to allow heavy cuts to be taken, either because it is too frail or because the heat generated will distort the piece, or both. In order to obtain the greatest possible economy in the milling operation, we must give the cutter the greatest possible number of revolutions and, after we have selected the smallest practical cutter, there is only one source of economy left and that is to increase the cutting speed. It was considerations like these that led up to the system of stream lubrication whereby unusually high speeds can be obtained with some intelligence and care. As stream lubrication not only prevents the cutter from heating unduly, but also keeps the work cool, it has a double effect on the economy of milling operations.

The foregoing considerations led the discussor to take exception to the statements contained in Par. 62. (As many teeth as possible.)

Fig. 3 shows the proportions of teeth as recommended by Messrs. Airey and Oxford, and also those recommended for wide-spaced cutters. The sketch shows a $3^1/_2$-in. cutter enlarged four times. The left-hand side shows the teeth as formed by the formula given in the paper and with twenty teeth in the cutter. The right-hand side shows the teeth, in black, as they are actually made; and in broken line as they would be made according to the formula given in the paper. It will be seen that there is but little difference between these two shapes—the actual shape being slightly the stronger. The main difference, however, lies in the fact that the broken-line shape requires a specially made cutter for generating the backs of the teeth, whereas the black shape can be formed by any cutter. When the land, as originally furnished, becomes too wide, it is a simple matter to grind the backs of the teeth with a cup wheel and to repeat this action as often as is necessary. So long as the size of the land is not reduced beyond the original size, the strength of the tooth will not be impaired. It is this practical reason which makes me advocate the shape as shown on the right hand side of the sketch.

Earle Buckingham,[1] who orally discussed the paper, was very much interested in the results obtained when using a spiral cutter, and offered the following explanation why these should show less effective results, namely, that the area of the surface of the cutter in contact with the chips becomes greater as the rake angle is increased thus creating more friction. This might explain the results obtained from using lubrication. The chips from some materials curl up more than those from other materials. If the chip clung closely to the face of the cutting edge, the lubricant might cause the chip to wring to the face in much the same manner as two gage blocks are wrung together, thus greatly increasing the friction. An analysis of the character and shape of the chips produced from different materials with the use of cutters of varying rake angles might shed some light on this.

The authors state that "the fine-tooth cutter will wear longer between grindings, due to the decrease in cutting speed." Too much emphasis cannot be given to the fact that a decreased cutting speed greatly increases the life of a cutter between grindings. The proportional increase in life is much greater than the proportional increase in speed. The speaker is acquainted with some very interesting tests made some five years ago to determine the effect of cutting speed on the life of a cutter. Tests were made at speeds of 70 and 80 ft. per min. with high-speed steel cutters on small nickel-steel forgings. The results were very consistent and showed that when running at 70 ft. the cutter would mill over twice as many pieces as when running at 80 ft. Thus two cutters of the same diameter, taking the same feed per tooth so that each would remove the same amount of material in the same time, etc., but with 21 teeth in one, for example, and 24 teeth in the second, would show a great difference in their life between grindings. If the conditions were identical to those mentioned above, the 24-tooth cutter would mill twice as many pieces. Thus should make apparent the importance of tooth-numbers in milling cutter design.

Frank B. Gilbreth[2] called attention to the fact that there was a field open to the makers of machine tools today which had not been utilized in the least, namely: The photographic record of the behavior of a tool and of the chip. It was now possible to take 2500 pictures per second stereoscopically with a penetrating screen.

Professor Airey, in closing the discussion, said that stereoscopic recording suggested by Major Gilbreth was the logical next step. They had done some slow-speed work in that field. They had taken ten or fifteen minutes to take out one chip, and had made records taking it in instalments.

Regarding Mr. De Leeuw's remarks on rigidity he was in accord with those. That was a fundamental, regardless of the particular cutting tool. As for the sharpness of the tool, not being capable of being absolutely definite, the test of that was in the machine

[1] Engr., Pratt & Whitney Co., Hartford, Conn. Assoc-Mem.Am.Soc.M.E.

[2] Pres., Frank B. Gilbreth, Inc., Montclair, N. J. Mem.Am.Soc.M.E.

belt. The author had realized that that was a possible source of trouble. They took from fifty to one hundred tests, and found they had to take a great number of chips, but there was no change in the energy, which was proof that the sharpness remained unimpaired. The chip thickness was zero at times, but it was known that the cutter could not get under the surface all at once. Just when it did get under we do not know, probably the photographing would clear that up.

Railway Session

The problem of eliminating waste in locomotive and car design and operation was given intensive treatment at the Railway Session on Tuesday morning. Two of the papers which were presented at this session had appeared previously in MECHANICAL ENGINEERING. These are Avoidable Waste in Locomotives by James Partington, in the November issue, and Avoidable Waste in Car Operation, by Walter C. Sanders, in the December issue. The remaining paper, on Avoidable Waste in Operation of Locomotives and Cars, by William Elmer, will appear in the February issue with an abstract of the entire discussion at this sesions.

Gas Power Session

The Gas Power Session was the first to be held by the reorganized Gas Power Division of the Society. With B. P. Flint, a member of the Executive Committee of the Gas Power Division, in the chair, two papers were presented, one by Louis Illmer, on the Porting and Charging of Two-Stroke Oil Engines, and the second by Elmer A. Sperry, on Compounding the Combustion Engine. There was practically no discussion on Mr. Illmer's paper and the meeting accordingly took up Mr. Sperry's paper, which appears elsewhere in this issue of MECHANICAL ENGINEERING.

In the opening discussion George A. Orrok[1] called particular attention to the transfer valve between the high- and low-pressure cylinders, which in Mr. Sperry's engine is the solution of a particularly severe problem. Mr. Orrok also emphasized the importance of mechanical atomization of fuel which has proven so successful when using fuel oil under boilers. He pointed out that the engine described by Mr. Sperry followed canons of steam-engine design.

Francis Hodgkinson[2] pointed out as important the increase of the size of compression space, which leads to detonation and is a remarkable aid to good combustion. A number of questions were asked as to the efficiency that could be obtained in this engine, and in closing the discussion Mr. Sperry stated that its thermal efficiency approaches the theoretical air-cycle efficiency, while the mechanical efficiency in the engines thus far constructed has been about 93 per cent. Mr. Sperry also outlined the possibilities of increasing the sizes of the compound engine and stated that with a 29 in. cylinder and a piston speed of from 800 to 900 ft. per min. there would be no difficulty in getting an 8000-hp. engine.

MANAGEMENT SESSION

THE MANAGEMENT Session at the Annual Meeting was presided over by Mr. L. P. Alford, Vice-President of the Society and former chairman of the Management Division.

As a basis for discussion of the central theme of waste elimination by efficient management, three papers were presented: Making Work Fascinating as the First Step Forward Reduction in Waste, by Walter N. Polakov; Process Charts, by Frank B. and L. M. Gilbreth; The Rochester Shoe Wage Arbitration, by Sanford E. Thompson, and two reports: Report of the Sub-Committee of the Management Division in Management Terminology, and Report of the Sub-Committee in Measuring Managerial Ability.

Mr. Polakov's paper was published in the December issue of MECHANICAL ENGINEERING; that by Mr. and Mrs. Gilbreth appears in this number, and Mr. Thompson's will be published later.

WRITTEN DISCUSSION IS VOLUMINOUS

Mr. Gompers wrote that the human element in production is the most important one, and labor realizes that upon management devolves the responsibility of developing the technique necessary to provide the methods whereby the creative ability we seek to conserve shall be released through opportunity to use brain, skill and human power in production.

Some of the written discussions of Mr. Polakov's paper were papers in themselves. For instance Mr. A. L. De Leeuw contributed a discussion of 3600 words, ascribing the entire causes of unrest to the demoralization of the world, and criticizing most palliative systems as failing to touch the underlying foundations.

Like Mr. De Leeuw, most of the discussors agreed with the author and their contributions were therefore more of the nature of supplements to the paper. However, L. W. Wallace, while praising the paper highly, could not concur in the statement concerning time studies. He wrote that he had not realized that there was any conscious effort being made towards decentralization of planning, nor of reuniting, instructing and inspecting functions of foremanship nor of substituting time-study with direct interchange of workers' skill and intelligence. It seemed to him that conscious effort in this direction would be a backward step and not absolutely necessary in removing the element of monotony.

Ralph L. Paddock wrote that the paper was filled with many opportunities for differences of opinions. However, he granted that by keeping well within the bounds of well-known facts the author proved his point.

Flattering the individual worker by calling him a "super-animal" and making his job more interesting, Reynold A. Spaeth agreed was essential for successful production, but he thought he saw signs of a deeper dissatisfaction—the monotonous grind of working perpetually for the interests of others, never for oneself.

Dr. H. S. Person[1] said he could not speak too strongly of his agreement with the central idea of the paper, but he told Mr. Polakov he intended to emphasize the points of disagreement. He thought the author used unnecessary philosophy, that he weakened his argument by a one-sided industrial history, that he explained the Taylor philosophy and system of management incorrectly, and that he did not concede to the personel manager sufficient credit in solving the problem of management.

PROCESS CHARTS, BY F. B. AND L. M. GILBRETH

Characterizing Mr. Polakov's paper as being concerned with the "why," Mr. Karl G. Kaisten wrote that Mr. and Mrs. Gilbreth's paper dealt with the "how." Mr. Polakov promised mankind a social system, while Mr. Gilbreth's paper "disclosed marvelous powers of dissecting human motion and activity." One paper was a "telescope" and the other a "microscope" and argument between them would be absurd.

Fred. Colvin[2] wrote that the authors' methods overcame the one great trouble with most records which are usually so delayed that they become merely post-mortems after the job is finished, and are not even always of value for the next job. It is not easy for either executives or workers to change their methods and habits, and an understanding of this phase of human nature is the first step toward efficient management.

M. L. Cooke[3] asked for information regarding the relation between the process chart and the route and instruction chart, and Mr. Gilbreth replied that the process chart is a definite scheme of visualizing the thing to be done. After the process chart comes the route chart and thirdly the instruction chart.

ELIMINATION OF WASTE THROUGH WAGE ADJUSTMENT

Mr. Sanford E. Thompson[4] was introduced as an arbitrator selected by the United Shoe Workers of America, in the Rochester Shoe Wage arbitration. His paper, which will appear later, described the events leading up to this arbitration and says "In the arbitration proceedings which resulted, there was presented by the workers as a substitute for wage reduction, a plan designed to lead up to the elimination of waste in manufacture through scientific methods, and the adjustment of wages on a scientific

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[2] Chief Engineer, Westinghouse Elec. & Mfg. Co., Lester, Pa.

[1] Managing Director, Taylor Society, New York, N. Y.
[2] Editor, Amer. Machinist, New York, N. Y. Mem.Am.Soc.M.E.
[3] Finance Bldg., Philadelphia, Pa. Mem.Am.Soc.M.E.
[4] 136 Fedral St., Boston, Mass. Mem.Am.Soc.M.E.

basis involving job analysis and time study." Then follows the award, a description of the Arbitration Board, and a brief treatment of the proceedings.

Mr. Thompson then discussed the two broad questions of: (1) Must wages come down, and if so how much, and when? Shall it be a flat charge or a real adjustment? (2) How should the workers themselves share in wage determination; illustrating his points with examples for the Rochester case.

As bearing in the problem of elimination of waste, Mr. Thompson quoted in extenso the proposal of the Arbitration Board for the permanent solution of both the wage and production problems:

"(1) That no wage reductions be recommended by the Board

"(2) That the existing piece-work and wage rates be placed on a strictly scientific basis as rapidly as the organization of joint administrative and technical machinery to this end will permit.

"In order to accomplish the purpose outlined in this proposal, the Shoe Workers request that joint administrative and technical machinery be established, based on the early recommendations of three technically qualified individuals, one selected by the manufacturers, one by the shoe workers and the third by the Arbitration Board. The duties of this committee are to be:

(*a*) To make a rapid survey of the Rochester Boot and Shoe Industry, *from the point of wastes and inefficiencies* and industrial relations.

(*b*) To determine the type and detailed organization of the coöperative administrative and technical machinery which the manufacturers should adopt for the purpose of establishing production standards.

(*c*) To suggest ways and means for *permanently remedying existing wastes and inefficiencies* in the local shoe industry.

(*d*) Pending the establishment of the scientifically correct production standards, and the elimination of wastes and efficiencies, existing piece work and wage rates shall not be lowered.

Reports of Subcommittees Presented

Mr. F. E. Town,[1] in presenting the progress report of the Joint Committee on Management Terminology, defined the scope of this work:

(*a*) to define management, and list and define the terms and phases of management

(*b*) to extend the Dewey decimal classification to cover management literature.

He described the organization of the committee—with six societies participating, each with two representatives and an alternate, and then outlined the work that had been done to date.

Four sub-committees were appointed, on Society Coöperation, on Ways and Means, on Finance and on Program.

The committee has succeeded in making a master alphabetic list of management terms, also a list classified under four groups for convenience, and these lists have been sent out to some 230 colleges which have promised to coöperate in supplying definitions of these terms and doing the necessary research work.

A vote of thanks was extended to the committee for their progress so far.

The second report presented was a prelimary report by the Sub-Committee in Standardization of Graphics. Mr. J. J. Swan[2] presented this subject, stating that the purpose of this committee was to standardize the "short-hand methods of presenting business, industrial and technical data."

The work of the committee was only just started, and the members would be very glad to receive suggestions from anyone in the Society.

The third report, on a Study of the Units and Methods of Measurement of the Managerial Function, was presented by Mr. A. L. De Leeuw.

The functions of management consist of three items: Promotion (and Extension), Production and Sales. In order to confine itself to that part of the investigation which would offer the best promise of results in the near future, the Committee had worked only on the managerial function concerned with Production. This in turn is manifest in three directions: Organization, Preparation and Direction.

Under the heading of Organization we have the Evaluation Chart, prepared by the Waste Committee, under Preparation, we have such items as Time Study, Motion Study, Basis of Wages; and under Direction, we find control charts.

The report recommends the consideration of ways and methods to obtain the necessary data required for:

Organization

Balance of Responsibility and Authority

Preparation

Effectiveness of purchasing
Adherence to standards
Basis of wages in Industry
Balance of sales and production

Direction

Labor stability—factor and data
Labor attendance—factor and data
Continuity of working conditions—factor and data
Material turnover period—factor and data.

At the close of the discussion of this report the following motion was passed:

That a vote of appreciation be accorded the committee, and that they be asked to continue the study and present their conclusions to the Management Division, and thirdly,

That the Executive Committee of the Management Division consider the advisability of asking the American Engineering Council to undertake an investigation of a basis for wages in industry.

Forest Products Session

The problem of conservation of forest products was given careful consideration at the meeting of the Forest Products Division. The principal speaker was David L. Goodwillie of Chicago, Ill., who told of the work being done by the United States Chamber of Commerce in their appointment of a Commission on Conservation and Reforestation. This Commission of twelve has traveled through thirty-seven states and has met with the men in the different branches of the lumber industry who are interested in a national policy for forest conservation. The effect of taxation on conservation, the importance of waste utilization, the control of competition and the restriction in timber cutting were all discussed. Mr. Goodwillie told in detail of the project at Bogalusa, where every portion of the lumber and waste is being utilized in factories where the handling is done entirely by machinery. The plans are laid with remarkable vision and the regrowth of timber in a comparatively short time is actually being accomplished.

Dr. Hugh P. Baker, of the American Paper and Pulp Association, told of the various methods of reforestation that will permit of a greater utilization of waste timber land. Discussion was contributed at this meeting by Joseph H. Wallace, George M. Hunt, Paul Porter, and Dr. Cruikshank on various methods of increasing the utilization of forest-products waste. Mr. Goodwillie's talk and the consequent discussion will be given more complete treatment in a later issue of MECHANICAL ENGINEERING.

Fuel Session

The Fuel Session was held Thursday with Professor L. P. Breckenridge, Chairman of the Fuels Division, acting as presiding officer. The program of excellent papers filled the auditorium and elicited a great deal of interesting discussion. Abstracts of the papers have appeared in MECHANICAL ENGINEERING. The paper by Victor J. Azbe on Boiler Plant Efficiency appeared in the November issue as did the papers by Joseph Harrington on Fuel Saving in Relation to Capital Necessary and by W. B. Chapman on Gas Producers and Industrial Furnaces. The masterly contribution by Dr. D. S. Jacobus appeared in December MECHANICAL ENGINEERING. An account of the discussion will be brought out in the February issue.

Elimination of Waste Through Efficient Materials Handling

THE Materials Handling Division of the Society, comprising 1400 members, staged a session on Thursday afternoon of the Annual Meeting, devoted to Materials Handling an Important

[1] 250 Eleventh Ave., New York, N. Y., Mem.Am.Soc.M.E.
[2] 30 Church St., New York, N. Y., Mem.Am.Soc.M.E.

Factor in the Elimination of Industrial Waste. Mr. Robert M. Gates, the active chairman of the Division, presided, and Mr. H. V. Coes, a member of the Division's Executive Committee, presented the one paper of the afternoon, which was discussed at great length. This paper was published in the December issue of MECHANICAL ENGINEERING.

In presenting the paper, Mr. Coes stated that there was a great lack of information as to the best materials-handling equipment for a given purpose. He thought professional engineers could perform a great service if they could show the means available for handling materials.

Mr. Coes illustrated his remarks with a series of lantern slides, showing the evolution of such familiar apparatus as the portable belt conveyor, the stevedore truck, etc., and including practically all of the present methods of mechanical handling.

Mr. Coes predicted that mechanical handling of materials would be extended considerably within the next few years, and that problems now outstanding would be solved. It is the duty of engineers who lay out plants to insist at the start that designs provide for proper handling of materials.

DISCUSSION

Mr. J. A. Shepard[1] agreed with the author's statement that "modern civilization is the direct result of the application of the principles of the sub-division of labor." He pointed out, however, that each sub-division of labor introduces an intermediate

AT THE MATERIALS HANDLING SESSION

Left to right, back row: W. N. Dickinson, M. F. Lawrence, R. H. McLean, H. E. Whitaker; front row: F. A. Wardenberg, H. V. Coes, R. M. Gates, N. C. Johnson, K. Dodge.

materials-handling problem which, if not properly solved, partially neutralizes the undoubted advantages of the sub-division. "Handling 168 tons of materials per ton of finished castings" summarizes the problem as it affects the foundrymen, but this statement gives no indication of the further problem of handling the casting through sub-divided finishing processes to wholesaler, retailer and finally consumer—rolling up a grand total of materials handling. Yet this is the situation concerning practically every commodity before it reaches the ultimate consumer. Mr. Shepard enunciated the following principle:

"Owing to the great number of relatively simple handling operations entailed by the sub-division of labor, efficient handling, together with a low capital cost for handling equipment, is likely only through the choice of a type of handling machinery capable of the greatest possible flexibility and mobility, thus enabling each unit of handling machinery to perform the maximum number and variety of handling operations.

"Moreover, the extent to which any type of handling equipment will occupy building or yard room which would otherwise be available for production processes, must necessarily become an important factor in making a choice."

Sam L. Libby,[2] following Mr. Shepard, criticized the manufacturers of materials-handling equipment whose attitude, he said, had been to sell as much of their machinery as possible. He thought one of the best things the Materials Handling Division could do would be to bring all the manufacturers to agree in a broad viewpoint of the problem.

H. M. Lane[1] emphasized, first, the need for coöperation, between the material handling people of radically different classes so as to get the right equipment for a given set of conditions; and second, the importance of the coöperation of the architect, without whom the plans of the materials handling man could easily be set at naught.

W. N. Dickinson, R. H. McLean, J. G. Hadfield, M. F. Lawrence, Wm. F. Hunt, and W. C. Brinton, also contributed to the discussion, and all agreed that the problem upon which Mr. Coes had concentrated attention was worthy of further consideration and detailed study by the Materials Handling Division of the Society.

[1] Vice-Pres. and Ch. Engr., Shepard Elec. Crane & Hoist Co., Montour Falls, N. Y. Mem.Am.Soc.M.E.

[2] Managing Engineer, Hoist Dept., Sprague Elec. Wks., Bloomfield, N. J. Mem.Am.Soc.M.E.

Students Conduct Important Session

Under the auspices of the Committee on Relations with Colleges and under the direct supervision of Dr. H. G. Tyler of this committee, the members of the Student Branches of the Society conducted a session on Thursday morning. An innovation in the meeting activities of the Society and in its relations with students, this session considered two technical papers and a statement of the problems of Student Branch operation in a manner equal to if not better than some of the sessions conducted by mature members of the Society.

Before the session opened, prominent members of the Society and the profession mingled with the students and explained the ideals of the Society and its scope of activities.

Dr. W. H. Kenerson, newly elected chairman of the Committee on Relations with Colleges, presided at the formal presentation of the following papers: Draft-Tube Design with Reference to the Hydraucone by W. K. Ramsay of M. I. T.; and Flow of Water in Hydraulic-Turbine Draft Tubes by George E. Lyon of R. P. I. Both papers were presented by the authors. They will appear in a later issue of MECHANICAL ENGINEERING with the pertinent discussion.

The balance of the three hours devoted to this session was given over to a discussion of the problems of Student Branch organization and operations. J. M. Spitzglass of Chicago told of the successful methods used at the Armour Institute Student Branch.

Over two hundred students attended and while the representation of New York schools was high, there were still a great many from outside, some coming from Atlanta, New Orleans, Pasadena and Cincinnati.

Conference on Research

A better interchange of scientific and research information through the agency of the Engineering Division of the National Research Council is within reach if the ideas developed at the Research Conference of the Annual Meeting and transmitted to Mr. A. D. Flinn, vice-chairman of the Division, who was present, are carried out.

This conference, held Thursday, December 8, was conducted by Prof. A. M. Greene, Jr., chairman of the Society's Research Committee, and the attendance of over forty included many authorities on engineering research. Two sessions were held, culminating in the organization of an Advisory Committee to help the National Research Council in the correlation of research data as well as to make suggestions to hasten the completion of the Council's scheme.

It was generally conceded that publicity would be the most effective method of eliminating waste in research, caused chiefly by duplication of effort, by lack of a coördinated and coöperative research program and by failure to adequately define the research problem before inaugurating experimental work.

To circumscribe the discussion somewhat and to confine it to the Annual Meeting topic—elimination of waste—four items were scheduled on the program, two being technical papers and two reports of committees. The papers were Elimination of Waste in Industry through Research, by F. A. Wardenburg,[2] and Research in Leather Manufacture, by Arthur W. Thomas;[3] the re-

[1] Pres., Lane & Bodley Co., Cincinnati, Ohio. Mem.Am.Soc.M.E.

[2] Asst. Ch. Engr., E. I. duPont de Nemours & Co., Wilmington, Del.

[3] Professor Food Chemistry, Columbia University, New York, N. Y.

ports were those of the Sub-Committee on Lubrication and of the Sub-Committee on Steam Table Research. Messrs. Wardenburg and Thomas presented their papers in person. The lubrication report was presented by Mr. Albert Kingsbury, Kingsbury Machine Works, Philadelphia, chairman of the committee, and the steam table report by Mr. George A. Orrok, consulting engineer, New York, and by Dr. H. N. Davis, Harvard Engineering School, who is conducting a portion of the steam-table research.

Mr. Wardenburg detailed the possibilities of research work in the reduction of manufacturing costs, citing several examples in the war which had resulted in the saving of millions of dollars. He then described a plan for conducting commercial research work under the commercial incentive, and secondly a suggested coöperative plan for conducting general research work. As an element of the latter he suggested the collection of a large fund for research to be placed under the jurisdiction of some central body, like the Research Committee of this Society, which would plan and carry out the research program.

Mr. Thomas then presented his paper on research in leather manufacture, concluding with the significant statement that though leather had been in use for many centuries, we are only just beginning to find out the elementary chemistry of the reactions involved in its manufacture. He quoted this as an example of the magnitude of the general research problem in the industries.

The question of duplication of research was discussed considerably at the meeting; but when the ideas of all the speakers were brought out, the impression was left that though almost every problem is being investigated by more than one agency, the phases are all different and each investigation practically constitutes a separate piece of work. Mr. Flinn described how the "card-index" of the National Research Council would furnish an excellent means of posting everyone on what everyone else was doing.

In presenting the progress report of the Sub-Committee on Lubrication, Mr. Kingsbury pointed out the inherent difficulties in undertaking any measurements in a film of lubricant within a few thousandths of an inch of space. He described the experimental work of the committee in the field of increase of pressure on lubricants. He illustrated his remarks by means of curves prepared by Mr. Mayo D. Hersey, professor at Massachusetts Institute of Technology, Department of Physics, who was doing the experimental work.

In connection with the steam-table research Dr. Davis said that he felt "very hopeful" that his organization would soon be able to get something on the Joule-Thomson effect, which was his assignment in this research. Dr. S. W. Stratton, director of the U. S. Bureau of Standards, supplemented Dr. Davis by telling just where the Bureau stood in its part of the investigation, and Mr. Orrok closed by reporting how the money was coming in, stating that the prospects were very bright for the collection of the seventy or eighty thousand dollars necessary, and for the completion within three years of this very necessary extension of the upper limit of the steam tables.

Among other prominent speakers at the session were Prof. H. F. Moore, of the University of Illinois, who is in charge of the important research on Fatigue of Metals being conducted with the assistance of Engineering Foundation; Dean Anderson, in charge of the research program of the American Society of Heating and Ventilating Engineers; H. C. Dickinson, research director of the Society of Automotive Engineers; and Prof. P. C. Walker, dean of the Engineering School of the University of Kansas.

Professional Engineering Education for the Industries

The Society for the Promotion of Engineering Education joined Thursday afternoon with the A.S.M.E. in a session of three papers on the relations between engineering education and the industries as follow:

Professional Engineering Education for the Industries, F. C. Pratt,

A National Policy on Engineering Education, A. G. Christie,

College Education as Related to Industry, J. E. Otterson,

Professor Charles F. Scott, President of the S.P.E.E. presided. The three papers with the ensuing discussion opened by Dean Dexter S. Kimball are published on the first pages of this issue.

Credit is due Professor Dugald C. Jackson who arranged the program which attracted large attendance and developed exceedingly interesting discussion.

Stresses in Flat Cylinder Heads

The able paper by Major Gilbert Dudley Fish on Stresses and Deformation in Flat Circular Cylinder Heads was presented on Thursday afternoon at the first General Session of the Annual Meeting. Professor Robert H. Fernald presided.

Major Fish's paper was a mathematical analysis of form and loading of elastic disks where the thickness is uniform and where all strains are within the limits of true elasticity. Although of great value, the paper was highly specialized in its contents and the discussion could be entered into only by those who had actually attacked similar problems. An abstract of the paper with a résumé of the discussion presented will appear in a later issue of MECHANICAL ENGINEERING.

Motion Pictures of Combustion

On Thursday afternoon R. Sanford Riley of Worcester, Mass., presented moving pictures showing actual conditions in a stoker-fired furnace. The great interest aroused in this exhibition made its repetition necessary. There was universal comment as to the value that these pictures will render in the development of a science of furnace combustion and in a later issue of MECHANICAL ENGINEERING there will appear an account of the preliminary work done by Mr. Riley in determining the successful methods of preparing the motion pictures.

Motion Pictures of Handling Materials

Following out the custom inaugurated at the Spring Meeting the Materials Handling Division enjoyed an exhibition of motion pictures which showed the development of apparatus for handling coal and lime stone by machinery. These pictures, displayed by the Robbins Conveying Belt Company, were shown in place of the usual excursion.

Second General Session

The Second General Session of the meeting was held Friday morning with Dr. D. S. Jacobus in the chair. Of the three papers presented, one by Paul A. Bancel on Steam Condensing Plants appeared in the November issue of MECHANICAL ENGINEERING. The paper by F. W. Dean on Testing Emergency Fleet Boilers using oil fuel will appear in the February issue of MECHANICAL ENGINEERING and the paper on the Vertical Triple Expansion Pumping Engine by L. A. Quayle and E. H. Brown will appear in the March issue. The discussions pertaining to each of these two papers will appear with them. The present account will therefore only include the discussion on Mr. Bancel's paper.

In a written discussion, Professor A. G. Christie complimented the author on the presentation of new ideas on condenser operation and design, especially of the air cooler. He asked for additional information about the causes and nature of tube corrosion and for data on water velocity, on pressure loss through a single-pass condenser with high water velocity, and on methods of obtaining higher heat transfer through the tube surface.

D. K. Dean,[1] in a written discussion, combatted Mr. Bancel's statements regarding the tube layouts in which steam lanes are used to assist steam distribution, on the ground that there was lack of test evidence in the paper. He stated that the Bancel design is deficient in that it is difficult to distribute the steam equably to the ends of the condenser. Mr. Dean also made a detailed comparison of water temperature distribution in a double-pass condenser with the distribution in the single-pass condenser advocated by Mr. Bancel. He showed that the single-pass condenser gives a poor division of work along the tube length. He further pointed out that the ratio of cooling surface to the amount of steam condensed is well established and requires the use of two passes to utilize commercial tube sizes.

[1] 88 Broad St., Boston, Mass.

Mr. John F. Grace[1] criticized Mr. Bancel's use of a small tube, single-pass condenser with a high water velocity through the tubes on the grounds that small tubes clog and require high-power circulating pumps. He deemed it wise to use a moderate velocity and to clean the tubes occasionally. He stated that it was his experience that tube losses increase as the tube surface is decreased.

A written discussion by Mr. F. E. Reynolds[2] reviewed developments in condenser design which have followed a seemingly aimless path. He stated his belief that the design of Mr. Bancel permitted heat transfer in an atmosphere of pure steam. He regretted the lack of data about this feature. Mr. Reynolds touched on the relative merits of single- and double-pass condensers and pointed out that the double-pass type gives equal distribution of condensation over the tubes.

Mr. E. B. Ricketts[3] decried the lack of test data on the heat transfer in this type of condenser.

At the end of the discussion, Mr. Bancel promised to answer the questions in a written closure.

Aeronautic Session

Joseph A. Steinmetz, Chairman of the Aeronautic Division, opened the Aeronautic Session on Friday morning with an optimistic word for the future of aviation and for the future of the work of the Division in assisting the development of aviation especially for commerce. He then turned the meeting over to Professor E. P. Warner, Chairman of the Aeronautic Papers Committee who took the chair. In his opening remarks, Professor Warner explained the principal purpose of the Aeronautic Division to be the dissemination of facts regarding aerial transport.

The titles and authors of the papers presented at this session were as follows: Commercial Operations of Airplanes, by L. B. Lent, Air Lines and Some of Their Problems, by R. B. C. Noorduyn, Study of the Elastic Properties of Small-Size Wire Cable, by R. R. Moore, Tests of Plywood Webs With Lightening Holes Arranged as in Airplane Ribs, by D. T. Brown and R. J. Diefenbach.

The paper by Major Lent appears in another column of this issue. The other papers will appear in a later issue accompanied by the discussion relating to them.

Major Lent's paper presents data of great value to the problems of commercial aviation and with Mr. Noorduyn's paper, it incited discussion that indicated great possibilities in commercial aviation in the immediate future. In closing the discussion, Major Lent emphasized the seemingly important point that the aeroplane offered greater commercial possibilities as a freight express or mail carrier than in transportation of passengers.

Lieutenant E. E. Aldrin, Secretary of the Division, newly arrived from a trip abroad was at the meeting and he gave some interesting first-hand information relative to commercial flying in Europe.

Textile Waste Session

Mr. Charles T. Plunkett, Chairman of the Textile Division presided over this Session on Friday morning at which the Textile Division presented a program dealing with wastes in the textile industry. The papers on Hidden Wastes in Textile Plants by T. P. Gates and Economy in Textile Drying by B. R. Andrews will appear with their discussion in the March issue of MECHANICAL ENGINEERING.

Charles T. Main opened the meeting with a report of the World Cotton Conference held in England last summer which he attended as a delegate of the Textile Division of the A.S.M.E. Mr. Main emphasized the fact that the British cotton manufacturers have joined in contributing about one million dollars for cotton research work. They have planned a large laboratory and they expect to take up the problems bearing on the manufacturing and finishing of cotton. Mr. Main spoke also of the movement on foot in this country to unite all bodies engaged in textile-research work in coöperation with the International Cotton Research Committee. The Cotton Conference itself impressed Mr. Main by the opportunity it offered for men from widely separated parts of the world to come together and partake of the wealth of information offered at the formal meetings of the conference and informally in the social gatherings.

Ordnance Session

The first session of the Ordnance Division held at an Annual Meeting of the Society was called to order on Friday morning by Waldo H. Marshall, Chairman of the Division. General Guy E. Tripp, Chairman of the Board of the Westinghouse Electric and Manufacturing Company, made the opening address in which he emphasized the responsibilities of the Ordnance Division and all those who have had experience in the production of ordnance material in the development of an organization to supplement the permanent staff of the Ordnance Department.

The principal paper of the session was delivered by Colonel J. W. Joyes, Chief of the Technical Staff, Ordnance Department, U. S. A. Colonel Joyes discussed the conditions in the past in the Ordnance Department and present indications of an effort to practice economy and save money. He discussed the limitations of tolerance in ordnance material which were somewhat troublesome during the war and indicated that the present effort is to study carefully the producability of the various articles of ordnance. The coöperative work between the army and navy in matters of design of ordnance was briefly reviewed. The showing was very satisfactory and duplications and wastes of effort in design are generally being avoided. The development of the Ordnance Department organization to prevent waste in overlapping was also explained by the speaker. He closed his address with an explanation of the policy of the Ordnance Department in investigating the possibilities of commercial articles before taking the design for strictly military uses.

CHAIRMEN OF THE SUB-COMMITTEES OF THE ANNUAL MEETING

Left to right, back row: G. R. Tuska, *President's Reception;* J. I. Lyle, *Informal Get-Together;* L. B. McMillan, *General Chairman;* W. S. Bowen, *Information;* H. D. Edwards, *Excursions;* Mrs. F. T. Chapman, *Ladies' Tea;* Mrs. Nixon Lee, *Ladies Acquaintanship;* Miss Burtie Haar, *Ladies Excursions;* E. Van Winkle, *Dinner Dance.*

Discussion at the session was contributed by Frank B. Gilbreth, Carl G. Barth, Fred J. Miller, F. G. Spencer, Captain Kimberly, R. D. Coleman, H. C. Spaulding and E. L. Sherwood who contributed problems relating to the design, specifications and manufacture of ordnance material.

[1] Harrison, N. J. Mem.Am.Soc.M.E.
[2] 95 Liberty St., New York, N. Y. Mem.Am.Soc.M.E.
[3] 241 East 15th St., New York, N. Y. Mem.Am.Soc.M.E.

Heat Balance of the Connors Creek Plant of The Detroit Edison Company

By C. HAROLD BERRY,[1] and F. E. MORETON,[2] DETROIT, MICH.

THE term "heat balance" is currently used in two different senses. At times we speak of the heat balance when we mean a physical condition in the plant whereby there is a balance of certain heat-absorbing and heat-developing capacities. Again, by heat balance we mean a thermal balance sheet which records the ultimate disposition of all the heat developed from the fuel used.

This paper discusses the heat balance in both senses for the Connors Creek Plant of The Detroit Edison Company. We shall first describe briefly the apparatus in the plant, following this by a discussion of the ideal operating conditions, and finally presenting actual results. The plant is considered just as it stands, without reference to changes now under consideration or construction.

Description of Equipment

The main turbo-generators are six in number—three[3] of 20,000 kw. capacity, one of 30,000 kw. capacity, and two of 45,000 kw. capacity, giving a total installed capacity of 180,000 kw.[4] The turbines are served by fourteen boilers, each of 2365 boiler hp. builder's nominal rating.

The boiler-feed pumps are steam-turbine-driven, with the exception of one which is motor-driven. One general-service water pump is steam-turbine-driven. All other plant auxiliaries are motor-driven, some by alternating-current motors, some by direct-current motors, the choice depending upon the nature of the driven unit. As it works out, those auxiliaries whose uninterrupted running is essential to plant operation are all driven by direct-current motors, while auxiliaries whose stoppage does not immediately affect the rest of the plant are driven by alternating-current motors. This

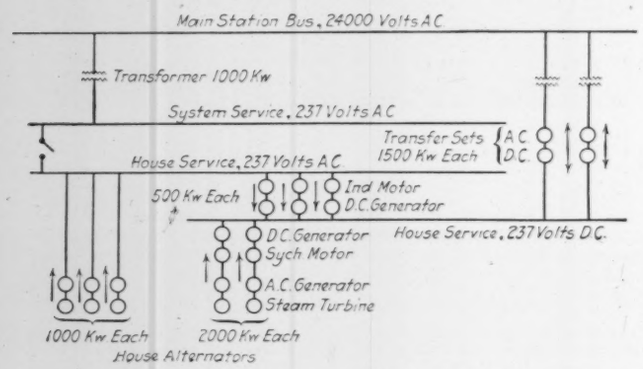

Fig. 1 Arrangement of Auxiliary Electrical System, Connors Creek Plant

division is not due to any belief in the superior reliability of direct-current motors, but is due to the fact that most, if not all, of the essential auxiliaries are of such character as to require or benefit from widely variable speed. Such are stokers, blowers, hot-well pumps, dry-vacuum pumps, circulating pumps,[5] etc.

The arrangement of the auxiliary electrical system is shown in Fig. 1. Alternating current for auxiliaries is available from either of two buses: (*a*) The "system service" bus, which is fed through a transformer from the main station bus, or (*b*) the "house service" bus, which is fed by three 1000-kw. turbo-generators. A tie switch is provided whereby these two buses can be connected. When this tie switch is closed, such of the 1000-kw. house alternators as are running must perforce operate in parallel with the main units. When this is done (and it is common practice at Connors Creek), the governors of the small units are set for a speed slightly above system frequency, and the house units are operated on the hand throttle, with constant steam flow and virtually constant load.

Direct current is available from a single bus (actually constructed as a ring). Owing to the importance of continuous service from the motors connected to this bus, it is fed from four sources:

a Two 1500-kw. steam-driven direct-current generators. Each of these consists of a turbo-alternator permanently connected (by bolted links) to a synchronous motor-direct-current generator set, so that the combination is merely a steam-driven direct-current generator with an electrical speed reduction instead of gears.

b Three 500-kw. motor-generator sets (induction motors) driven from the house-service alternating-current bus.

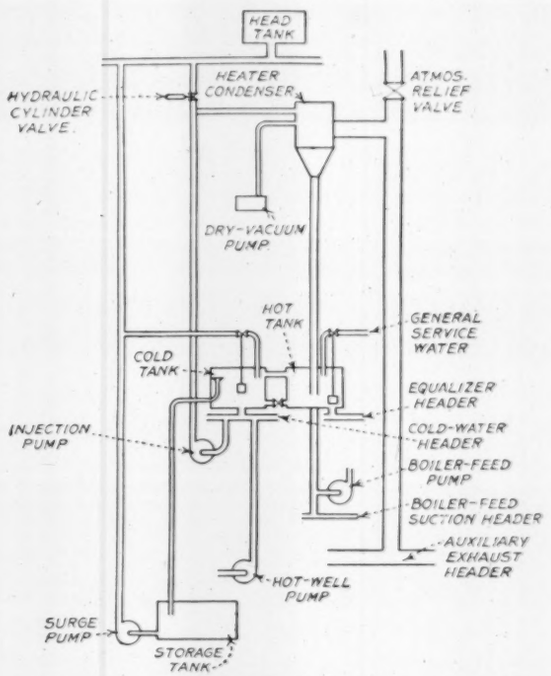

Fig. 2 Arrangement of Auxiliary Exhaust-Steam and Feedwater Heating Apparatus, Connors Creek Plant

c Two 1500-kw. motor-generator sets (synchronous motors) driven from the main station bus. These sets have characteristics and controls such that they may deliver power in either direction, wherefore they are known as "transfer sets."

d A storage battery of 1500 amp-hr. capacity.

An important characteristic of a system of this sort is that the load on the auxiliary steam turbines is independent of the auxiliary power demand of the station. With the tie switch closed between the system service and house-service buses, and with the transfer sets operating between the main system and the house-service direct-current bus, the house-turbine loads may be adjusted at will, within limits set by the capacities of the apparatus.

The function of the house turbines is twofold:

a To furnish a standby source of power for station auxiliaries in the event of a system failure, and

b To furnish exhaust steam for boiler-feedwater heating.

Fig. 2 shows the arrangement of the auxiliary exhaust-steam

[1] Engineer, Vice-President's office, The Detroit Edison Company.

[2] The Detroit Edison Company.

[3] At the present writing one of these is in the manufacturer's plant in the course of rebuilding. A 10,000-kw. unit stands in its place.

[4] For the time being 170,000 kw.

[5] At the time of writing, the older of these pumps still have induction motors, which are to be displaced by direct-current motors.

Abstract of the fourth of a group of papers presented at the Power Waste Session of the Annual Meeting, New York, December, 1921, of The American Society of Mechanical Engineers. The other three papers appeared in the December, 1921, issue of Mechanical Engineering, pp. 790–795.

and feedwater-heating apparatus. The auxiliary exhaust heater receives the exhaust steam from five house turbines, from six boiler-feed-pump turbines, and from one general-service-pump turbine, as well as the vapor formed in the boiler-feed make-up evaporators. This steam passes upward into five barometric-condenser heads, where it meets condensate from the main condensers. The resulting hot water is discharged into the hot boiler-feed tanks, whence it is

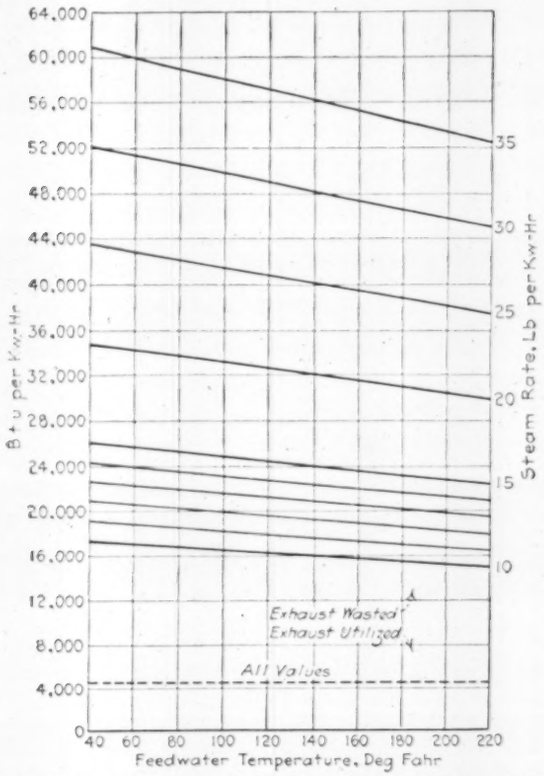

FIG. 3 COMPUTED COST OF POWER FOR VARIABLE TURBINE STEAM CONSUMPTION AND BOILER-FEED TEMPERATURE, WITH FIXED INITIAL STEAM CONDITIONS
(Steam pressure, 240 lb. per. sq. in. abs.; superheat, 200 deg. fahr.; boiler-room efficiency, 0.75.)

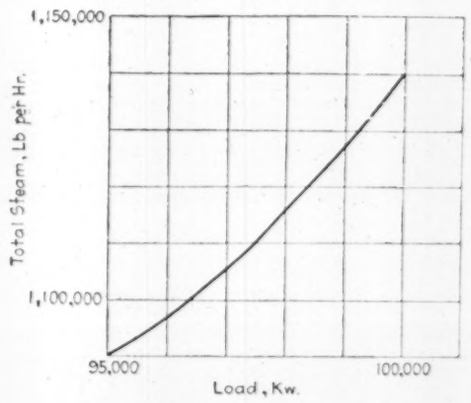

FIG. 4 TOTAL-STEAM CURVE OF MAIN UNIT

pumped into the boilers. The cold condensate piping and tanks are designed to care for variations in the volume of water in the boilers at times of variable plant load, and to safeguard the boiler-feed pumps against failure of the supply. Inasmuch as these barometric condensers serve as condensers for the auxiliary system and as feedwater heaters for the main system, they are known as "heater condensers."

THEORY OF OPERATION

There are two viewpoints from which to state the gain in station economy due to the operation of a system of this kind:

a A simple but approximate view—the substitution of cheap power for costly power

b A complicated but exact computation—a saving due to increased feedwater temperature, offset by an increased station steam consumption.

The matter will be discussed from each of these two points of view.

In the chart shown in Fig. 3 the full lines show the computed cost of power for variable turbine steam consumption and boiler-feed temperature, with fixed initial steam conditions. If we assume that all losses in the turbine appear as heat available from the exhaust steam, that is, if we neglect radiation losses, and if we recover usefully and credit to the turbine all of the heat available from the exhaust steam, then the cost of power is constant for all conditions, and is equal to the heat equivalent of a kilowatt-hour (3415 B.t.u.) corrected only for boiler-room losses. For the assumed boiler-room efficiency of 0.75, this gives us a cost of power of 4550 B.t.u. per kw-hr., and this is shown plotted in Fig. 3 as a dashed line.

In the case of a plant like Connors Creek, the main units have a steam consumption of, let us say, 12 lb. per kw-hr., wherefore power generated by them costs from 18,000 to 21,000 B.t.u. per kw-hr. The house turbine, whose exhaust heat we may assume to be fully utilized, produces power at a cost of 4550 B.t.u. per kw-hr. Clearly, the displacement of a portion of the power generated by the main units at high cost by power generated by the house turbine at much lower cost will result in a gain in station economy. From this it would appear that the maximum house-turbine output is to be

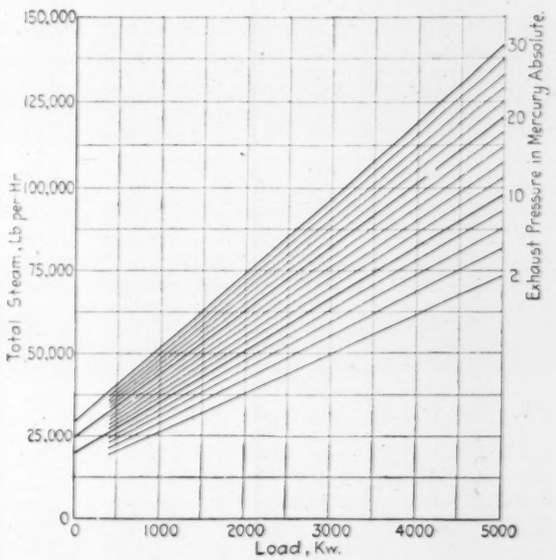

FIG. 5 TOTAL-STEAM CURVES OF HOUSE TURBINE

striven for. But the matter is not so simple, for here we meet the outstanding feature of the system—the auxiliary exhaust pressure may be adjusted to any value between the lowest attainable absolute pressure and atmospheric pressure. If we operate at a very low pressure, the auxiliary exhaust steam, and therefore the boiler feedwater, are at low temperature, with a resulting high cost of power from the main units. Further, with a small temperature rise of the boiler feedwater, very little exhaust steam can be condensed, wherefore the output of the house turbine is small. As the auxiliary exhaust pressure rises, the boiler-feed temperature rises, lowering the cost of power from the main units, and at the same time the heat absorption of the boiler feedwater increases, condensing more auxiliary exhaust steam and permitting the generation of more cheap power by the house turbine. As the auxiliary exhaust pressure continues to rise, however, another influence enters: the steam consumption of the house turbine increases, that is, the power output of a given steam flow will be less. This reduces the proportion of cheap power generated, and eventually a point is reached at which an increase of auxiliary exhaust pressure will decrease the station economy. Our problem is to locate this point of maximum station economy. It will be worked out in the more exact analysis which follows.

As is pointed out below, in discussing the results of this study, a complete analysis of this problem requires a large fund of infor-

mation, which unfortunately is not yet available for the Connors Creek plant. We shall therefore carry out this study for an assumed plant with characteristics consistent with the performance of Connors Creek. The results obtained will serve to define the problem rather than to present a solution for the actual plant. The following data are assumed:

Total station load, including auxiliary power demands, constant and equal to 100,000 kw.

Main unit steam consumption assumed to conform to the total-steam curve of Fig. 4

A house turbine of 5000-kw. capacity, whose performance is shown by the total-steam curves of Fig. 5[1]

Initial specific total heat of steam at 225 lb. per sq. in. gage and 200 deg. superheat = 1313 B.t.u. per lb.

Temperature of condensate leaving main unit condensers = 70 deg. fahr.

Boiler feedwater leaves the heater condensers at a temperature 10 deg. fahr. below the boiling point corresponding to the auxiliary exhaust pressure

Boiler-room efficiency equal to 0.75

Radiation neglected.

Our first step is to develop a very interesting relation which applies to any steam prime mover whose exhaust is wholly used for

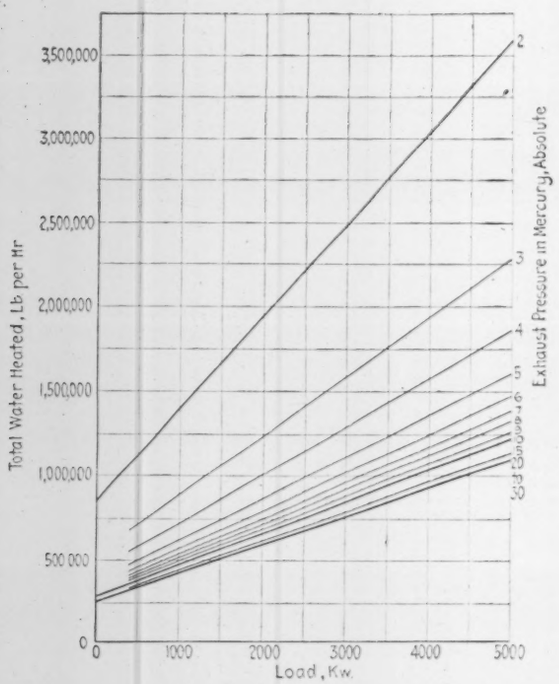

Fig. 6 Water Heatable by Exhaust Steam from House Turbine

heating water. If the water is heated from a constant initial temperature to a constant number of degrees below the boiling point corresponding to the exhaust pressure, then a curve plotted between the turbine load and the quantity of water capable of being heated will have the same shape as the curve plotted between turbine load and total steam. Proof of this fact is given in one of the appendices of the complete paper, where the relations involved for the conditions assumed above are developed. For these conditions the curves of Fig. 6 have been prepared.

We are now in a position to determine the cost of power for variable house-turbine load. Another appendix of the complete paper indicates the method and gives the computations in detail. The principal results are shown in Figs. 7 and 8. From the curves it is clear that the best station economy is obtained with a house-turbine load of 4500 kw. and a boiler-feed temperature of 160 deg. fahr. In Fig. 7 the small circles at zero house-turbine load indicate conditions with the house turbine shut down.

In interpreting these results, attention must be directed to the fact that the curve of cost of power is rather flat. Operation at a condition somewhat removed from the best point results in only a small increase in the cost of power. However, modern power-plant operation is largely concerned with small increments, and a gain of even 100 B.t.u. per kw-hr. is not to be neglected.

Attention must further be called to the fact that the computations here given are based on one set of assumed conditions. To carry out this study in general would require much detailed information. We should need the total-steam curve for the main units running in various combinations over the entire range of plant load. We should also need the total-steam curves for all house turbines (at Connors Creek, five house alternators, six boiler-feed pumps, one

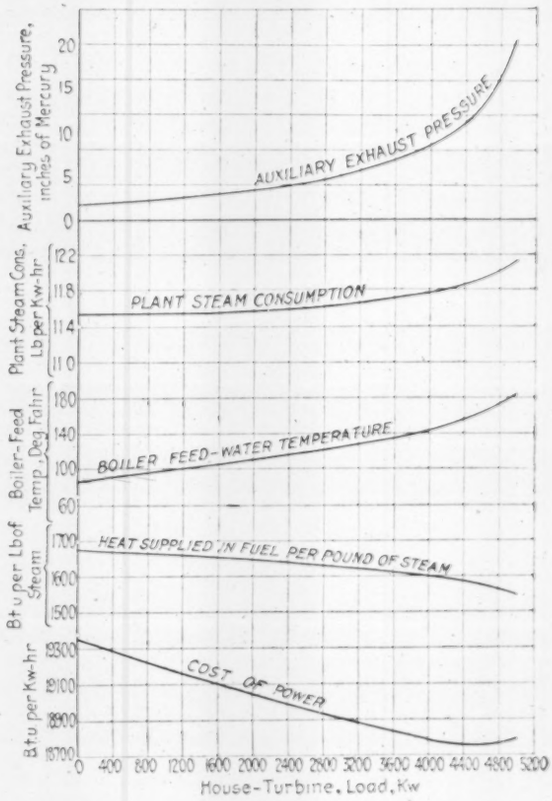

Fig. 7 Cost of Power for Variable House-Turbine Load

general-service pump—twelve turbines in all) over their entire range of load and exhaust pressure. We should then have to develop combined curves for various load distributions among these auxiliaries, and for each of these we should have to compute results

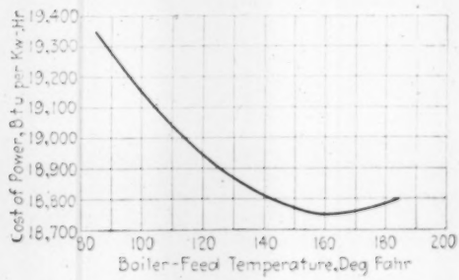

Fig. 8 Variation of Cost of Power with Boiler-Feed Temperature

for various plant loads and main unit distributions, for various values of the condensate temperature and for various values of the interval d by which the boiler-feed temperature is below the boiling point corresponding to the auxiliary exhaust pressure. This is obviously a large undertaking, and one for which we have not yet secured adequate data.

The main facts, however, are clear. For a system of this type there is a best point, and it is just as wasteful to heat the feedwater to a higher temperature as to a lower. We believe that for the Connors Creek plant the best economy is obtained with a boiler-

[1] These curves are based on an actual test of a 1000-kw. set, and probably indicate a higher steam consumption than is normal for a 5000-kw. unit.

TABLE 1 THERMAL BALANCE SHEET FOR APRIL 1921, THE DETROIT EDISON CO., CONNORS CREEK POWER HOUSE

The month of April, 1921, represents neither the best nor the current plant performance. At that time the plant was still operating with crippled units and with much equipment still in progress of recovery from post-war conditions.

Apparatus	Debit				Credit: Useful				Credit: Lost				Efficiency of Apparatus
		B.t.u. per lb. of coal	Per cent of heat value of coal	B.t.u. per kw-hr.		B.t.u. per lb. of coal	Per cent of heat value of coal	B.t.u. per kw-hr.		B.t.u. per lb. of coal	Per cent of heat value of coal	B.t.u. per kw-hr.	
Boiler	Coal	12349	100	20140	Steam to mains (sup.)	9875	79.97	16175	Moisture (hyd.)	560	4.53	914	$\frac{10454-1180}{12349} = 75.1\%$
	Air Main Alternator	59	0.48	96	Steam to mains (sat.)	579	4.69	945	Moisture in air	25	0.20	41	
	Air House Alternator	2	0.02	3					CO	65	0.53	106	
	Boiler Feed	1180	9.55	1927					Carbon in ref.	370	3.00	604	
	Radiation from Mains	33	0.27	54					Radiation	225	1.82	367	
	Work by B. F. Pumps	8	0.06	13					Dry gases	1932	15.65	3152	
		13631	110.38	22253		10454	84.66	17060		3177	25.73	5184	
Steam Mains	Steam from Boiler	10454	84.66	17060	Steam to turbines	9843	79.72	16070	Heating system	35	0.28	57	$\frac{9843+82}{10454} = \frac{9925}{10454} = 94.9\%$
					Steam to evaporators	82	0.66	134	Flue blowers	61	0.49	100	
					Radiation (mains)	33	0.27	54	Soot blowers	120	0.97	196	
					High press. Traps	3	0.04	8	Leaks (restaurant, etc.)	265	2.15	433	
					Heating system traps	10	0.08	16					
		10454	84.66	17060		9973	80.77	16282		481	3.89	786	
Turbines	From Steam Mains	9160	74.18	14960	Energy to shaft	2205	17.86	3600	Bearing friction	40	0.32	65	$\frac{2205}{9160-484} = \frac{2205}{8676} = 25.4\%$
					Packing loss	196	1.59	320	Radiation	10	0.08	16	
					To condenser	6709	54.33	10950					
		9160	74.18	14960		9110	73.78	14870		50	0.40	81	
Condenser	From Turbine	6709	54.33	10950	To condensate	484	3.92	790	To circ. water	6421	52.00	10480	
Condenser	From Turbine Packing	196	1.59	320									
		6905	55.92	11275		4.84	3.92	790		6421	52.00	10480	
Main Alternators	Energy from Shaft	2205	17.86	3600	To switchboard	2106	17.04	3437	Bearing friction	30	0.24	49	$\frac{2106}{2205} = 95.5\%$
					Ventilating air	59	0.48	96	Exciter loss	10	0.08	16	
		2205	17.86	3600		2165	17.52	3533		40	0.32	65	
House Turbine	Steam from Mains	568	4.60	927	Energy to shaft	51	0.41	83	Bearing friction	5	0.04	8	
					To heater-condensers	507	4.11	828	Radiation	1	0.01	2	
									Packing loss	4	0.03	6	
		568	4.60	927		558	4.52	911		10	0.08	16	
House Alternator	Energy from Shaft	51	0.41	83	To switchboard	43	0.35	70	Bearing friction	5	0.04	8	$\frac{43}{51} = 84.3\%$
					Ventilating air	2	0.02	3	Exciter loss	1	0.01	2	
		53	0.43	86		45	0.37	73		6	0.05	10	
Heater Condenser	From House Turbine	507	4.11	828	Feedwater	1185	9.60	1934	Radiation	5	0.04	8	
	From B.F.P. Turbine	105	0.86	173									
	Condensate	484	3.92	790									
	Evaporator	78	0.63	127									
	Storage Tank	15	0.12	24									
		1190	9.64	1942		1185	9.60	1934		5	0.04	8	
Boiler-Feed Pump Turbines	Steam from Mains	115	0.93	188	Heater-condensers	106	0.86	173	Radiation	1	0.01	2	
					Work on feed water	8	0.06	13					
		115	0.93	188		114	0.92	186		1	0.01	2	
Evaporator	Steam from Mains	82	0.66	134	To heater-condensers	78	0.63	127					
	Heat in Raw Water	1	0.1	2	To storage tank	5	0.04	8					
		83	0.67	136		83	0.67	135					
Boiler-Feed Tanks	From Feed Water	1185	9.60	1934	To boilers	1180	9.55	1927	Radiation	10	0.08	16	
	From High-Press. Traps	5	0.04	8									
		1190	9.64	1942		1180	9.55	1927		10	0.08	16	
High- and Low-Pressure Traps	From Steam Mains	5	0.04	8	To B.F. tank	5	0.04	8					
	From Heating System	10	0.08	16	To storage tank	10	0.08	16					
		15	0.12	24		15	0.12	24					
Storage Tanks	From Heating System	10	0.08	16	To heater-condensers	15	0.12	24					
	Evaporator	5	0.04	8									
		15	0.12	24		15	0.12	24					
Switchboard	From Main Alternators	2106	17.04	3437	Energy sent out	2093	16.95	3415	To stoker motors				Ratio Auxiliary to Net delivered kw-hr. $= \frac{656}{2093} = 2.68\%$
	From House Alternators	43	0.35	70					circulators				
									coal handling				
									blowers				
									compressor	56	0.45	91	
									D.V. pumps				
									transmission				
									miscellaneous				
									gen. service pumps				
		2149	17.39	3507		2093	16.95	3415		56	0.45	91	
Totals		47731	386.52	77901		37474	303.50	61164		10257	83.05	16739	

feed temperature lying between 160 and 180 deg. fahr., and in this range we try to operate.

Balance Sheet

The preparation of the accompanying balance sheet, Table 1, calls for the exercise of considerable judgment in selecting data, and even for some "directed guessing." The major items are, of course, taken from direct observations, but such things as radiation and drip losses are not susceptible of measurement by practical means, and must be estimated on the basis of other observed data or simply on general considerations.

DISCUSSION OF THE POWER WASTE SESSION

The Power Division held a session on Tuesday morning, December 6, devoted to the subject of power waste. Prof. A. G. Christie, Johns Hopkins University, presided at the meeting. Papers were presented as follows: Auxiliary System and Heat Balance at the Delaware Station of the Philadelphia Electric Company, by E. L. Hopping; Heat Balance of Colfax Station, by C. W. E. Clarke; Heat Balance System for Hell Gate Station, by J. H. Lawrence and W. M. Keenan; and Heat Balance of the Connors Creek Plant.

of the Detroit Edison Company, by D. Harold Berry and F. E. Moreton. The meeting was then thrown open to a discussion of the general subject of heat balance.

Prof. Arthur M. Greene, Jr.,[1] read a written discussion by John A. Stevens[2] in which he criticised the four plants discussed in the papers for operating at such low pressures and temperatures. He called attention to the recommendation in the report of the Superpower Survey of a pressure at the throttle of 300 lb. per sq. in. and a superheat of 230 deg. fahr., and submitted figures of the pressures and temperatures of important steam plants of this country, England and Europe. He expressed a belief that American engineers were following rather than leading English and French engineers in the development and use of high-pressure steam.

J. R. McDermet[3] read a written discussion of Mr. Hopping's paper with special reference to the proposed air extractors mentioned by the author. Mr. McDermet divided systems of driving central-station auxiliary apparatus into three groups, (1) by steam, (2), by house turbine with electric distribution and (3), by extraction heating. He said that it was possible by rather complicated mathematics to show that with an infinite number of extraction heaters following the turbine expansion, the power-station cycle reduces from the Rankin to the Carnot. While from practical considerations this infinite number of heaters is impossible, the extraction heater method has certain advantages which, he pointed out, made it an attractive method of obtaining heat balance.

The value which Mr. Hopping gave to vent loss from the heater appeared to Mr. McDermet to be roughly correct although possibly too low. The installation of air extractors as proposed in the Delaware Station has three advantages: first, elimination of vent loss heat in the operation of the heater which in the proposed installation should be reduced to approximately 0.5 per cent instead of 5 per cent; second, the loss of water through the heater vent in the form of steam will also be eliminated; and third, the reduction of temperature of feed from 210 to 140 deg. will give an added economizer effect and probably increase the boiler efficiency about one per cent. The air extractor which should be used operates upon the Elliot system of explosive boiling.

James M. Taggart,[4] in commenting on Mr. Hopping's paper, said it would be of interest to know the amount of increase in heat return realized by lowering the feedwater temperature to 140 deg. He also commended Mr. Berry's emphasis of the importance of speed control of auxiliaries. He considered that only a doubtful increase in reliability was being obtained at the Colfax Station by the use of turbine drive for forced draft fans and boiler feed pumps and that the sacrifice in economy was considerable.

John Anderson[5] asked why banking coal losses had not been included in Fig. 3 of Mr. Hopping's paper. He thought Mr. Hopping had used too high an economizer efficiency in view of the feedwater temperature of 210 deg. If pulverized coal had been used in the Delaware Plant a figure of 16,900 B.t.u. per net kw-hr. might have been obtained instead of the 17,982 B.t.u. actually obtained.

N. E. Funk[6] suggested that the Society standardize heat balance as it had standardized boiler testing, pointing out that in the papers presented three different methods had been used in presenting heat balances so that comparisons were difficult. He did not wish the impression carried away that the Philadelphia Electric Company was averse to electric drive for auxiliaries. He thought that automatic control appratus which could be started and stopped by push buttons was entirely satisfactory and would relieve operators of any except the most simple duties.

Mr. Funk was not in accord with the trend toward higher temperatures and pressures unless they were necessary in reducing the actual cost of producing current. The cost involved in operating under high boiler pressures and temperatures must be figured when any theoretical saving due to these changes is proposed.

Leo Loeb[7] spoke of the considerations involved in selecting drive for station auxiliaries and presented a summarized heat balance covering a week's operation at the Delaware Station.

Francis Hodgkinson[8] spoke of the delusion under which engineers had formerly labored that so long as steam from auxiliaries was condensed in the feedwater heater the water rate of these auxiliaries did not matter. Nine or ten years ago he had devised a series of valves for accomplishing heat balance which provided for bleeding the main turbine at a time of least efficiency in heating feedwater and supplying steam to the turbine when the reverse condition existed. One reason for leaning toward the electric drive was the elimination of undesirable conditions in the basement containing steam-driven auxiliaries. He thought that engineers generally were favoring the house turbine heat-balance scheme.

H. R. Summerhayes[9] also spoke of the necessity of having steam-driven auxiliaries of the highest economy if economy of the main unit is desired.

R. J. S. Pigott[10] pointed out the fact that the heat consumption of a plant varies with the load and that in order to determine the most economical combination of auxiliaries it is necessary to study more than one load. One system for obtaining heat balance might be the best for a given load while another system might be the best for a variety of loads.

L. P. Breckenridge[11] said that he was impressed with the desirability of serving industrial areas by power plants in which the heat energy of the coal could be converted into electric energy in the most economical way and called attention to the report of the Superpower Survey.[12]

T. E. Keating[13] spoke of the most economical boiler feed temperature which, he said, should be between 160 and 170 deg. if economizers are used.

Joseph Pope[14] said that the duplex drive offered difficulties in shifting load from the steam to the electric ends. He also spoke of the lack of speed control on large turbines at the auxiliary steam inlet connection which might result in overspeeding in case of a very light load on the turbines and a large supply of low pressure steam.

J. B. Scott[15] asked if the authors of the papers would install the systems of heat balance described by them in case the stations were to be redesigned.

George A. Orrok[16] spoke of the possibility of approaching the Carnot cycle in the power plant. He believed that the load factor at which the station was to run was the determining factor in choosing the auxiliaries to be used in working out a heat balance.

CLOSURE

E. L. Hopping, in closing the discussion on his paper, and in answer to a question which had been asked about burning oil, said that the furnaces at the Delaware Station were designed so that, with few alterations, oil or pulverized fuel might be used in place of stoker-fired coal. In answer to Mr. Anderson, he pointed out that the figures given in the paper included the standby losses. He called Mr. Hodgkinson's attention to the cleanliness of the auxiliary basement at the Delaware Station where steam-driven auxiliaries are installed. As Mr. Piggott had advised, a complete study of economies at all loads was entered into in deciding upon the auxiliaries for this station. In designing a new station, the speaker said, he would use all of the experience gained at the present and other stations in making a choice of auxiliaries.

C. W. E. Clarke, in referring to Mr. Stevens' suggestion of using

(*Continued on page 74*)

[1] Professor Mechanical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. Mem.Am.Soc.M.E.

[2] Consulting Engineer, Lowell, Mass. Mem.Am.Soc.M.E.

[3] Research Engineer, Elliott Co., Jeannette, Pa. Mem.Am.Soc.M.E.

[4] Consulting Engineer, Taggart & Perry, New York, N. Y. Assoc-Mem.Am.Soc.M.E.

[5] Chief Engineer, Milwaukee Elec. Ry. & Light Co., Milwaukee, Wis. Mem.Am.Soc.M.E.

[6] Operating Engineer, Philadelphia Electric Light Company, Philadelphia, Pa. Mem.Am.Soc.M.E.

[7] Day and Zimmermann, Inc., Philadelphia, Pa. Mem.Am.Soc.M.E.

[8] Chief Engineer, Westinghouse Elec. & Mfg. Co., Lester, Pa. Mem. Am.Soc.M.E.

[9] General Electric Company, Schenectady, N. Y.

[10] Crosby Steam Gauge & Valve Co., Boston, Mass. Mem.Am.Soc. M.E.

[11] Professor Mechanical Engineering, Sheffield Scientific School, Yale University. Mem.Am.Soc.M.E.

[12] Professional Paper No. 123, U. S. Geology Survey.

[13] General Manager, Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa. Mem.Am.Soc.M.E.

[14] Betterment Engineer, Stone & Webster, Inc., Boston, Mass. Assoc. Mem.Am.Soc.M.E.

[15] Consulting Engineer, Philadelphia, Pa. Mem.Am.Soc.M.E.

[16] Consulting Engineer, New York, N. Y. Mem.Am.Soc.M.E.

Compounding the Combustion Engine

By ELMER A. SPERRY,[1] NEW YORK, N. Y.

To engineers versed in the problems of selecting and designing prime movers, the advantages of the compound combustion engine are readily apparent. It is light compared with the normal Diesel, being in special cases, according to the author, less than one-tenth, and in some instances less than one-twentieth, the weight for the same output. Its mechanical efficiency is extremely high, and a distinct gain in overall efficiency from fuel to shaft is said to have been made, as well as a very definite gain in simplicity, direct performance and smoothness of the crankshaft diagram. This has been achieved while adhering to the best practice, namely, four-cycle operation.

This paper presents the results of research by the author extending over a series of years, during which it is claimed that not only has the high-pressure principle been thoroughly established, but all the important requirements have been worked out, and finally an engine embodying practically all the advantages has been subjected to long continuous runs.

THE high-compression or Diesel cycle in combustion engines has worked nothing short of a revolution, having brought to the prime mover its choicest heritage, the highest thermodynamic efficiency known. The fuel economies of these engines have forced them to the front. They have become extremely reliable and easy to operate; instances are becoming common of long runs without overhaul—long-continued performance without shutdown or forced stop of any kind.

As experience is gained with these engines, however, there have developed some objectionable features which are serious. Though they occupy somewhat less space than boilers and engines, the weights of Diesels are on a par with, if not somewhat in excess of, those of reciprocating engines with their boilers and decidedly in excess of those of water-tube boilers and turbines. The standard product of the largest builder of Diesel engines for the merchant service weighs about 450 lb. per shaft horsepower and is large and bulky. A substantial increase in tonnage of freight carried is only one of the gains that would be secured, could these engines be made much lighter and smaller for the same power.

The weight is not the only difficulty with these large engines, however, for they cost more than steam equipment of equal power. One instance of $200,000 excess for a 3500-s.hp. ship is cited. In another ship for the same service and of the same power the weight was 60 per cent in excess of the turbine equipment and the cost 212 per cent, amounting to $306,000 excess. Notwithstanding this extra capital charge, the first ship at three-fourths capacity in the Far East trade can earn nearly double net (83 per cent) over its turbine competitor of the same power and construction and with its machinery weighing a third more than steam equipment.[2]

Again, it has been found that almost without exception a grade of fuel oil known as Diesel oil must be employed. This is a partially refined product costing upon the present market considerably more than bunker oil burned under the boilers.

The fuel-oil problem in itself renders some advance absolutely imperative. Conservation of our oil should be backed by Government enforcement to stop the prodigal waste which results from bulk or furnace firing of enormous quantities of these highly concentrated fuels, destroying three to five times the quantity, power for power, required by steam, especially now since the cheapest petroleum can yield to the full its wonderful store of energy in the most direct way possible by being burned drop by drop directly in the cylinder and practically at the point where the work is to be done.

Compounding as a Remedy for Inherent Difficulties with Diesels—The Author's Early Work

In a report made by a group of engineers in 1900, it was stated that if the combustion engine could be successfully compounded, a most important gain would be made in its weight and size. The fact that compounding presents other advantages has been known to engineers for a number of years, but the difficulties have been looked upon as insurmountable.

A year ago Professor Watkinson, director of the important engineering laboratories of Liverpool University, in discussing an epoch-making paper by Engineer-Commander Hawkes on the Admiralty's extensive research on Diesels, stated, in substance, that we must recognize that the combustion engine in its present state was very crude and in compounding only lies the line along which the next great step in progress would be made. And he also stated that much greater results are bound to follow the compounding of combustion engines than were ever realized by compounding steam engines; first, because of the very much greater range of pressures available, and secondly, because the great enemy to compounding in steam, viz., condensation, is not present.

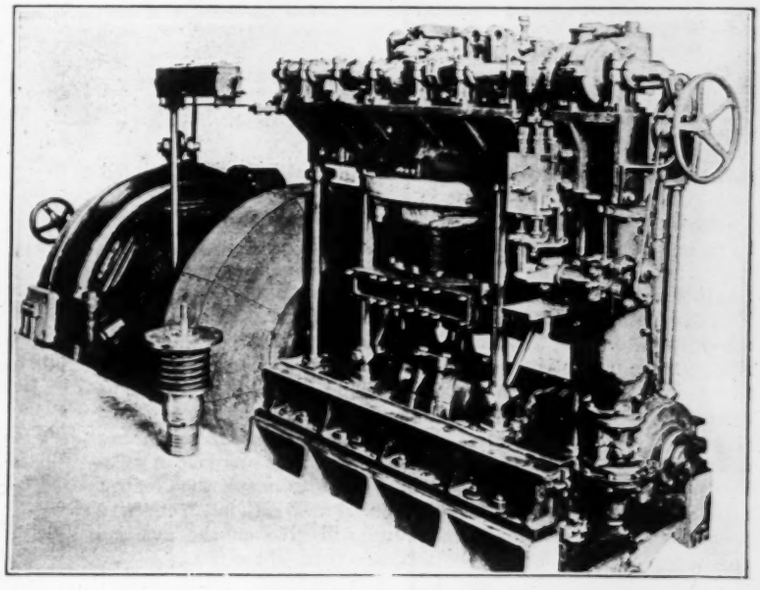

Fig. 1 10 : 1 Marine-Type Compound Oil Engine Built for Heavy Duty

Activity in this field is now prodigious and workers in various parts of the world are commencing to realize that a great advance step is imminent. In America, a group headed by the author has been engaged on this problem for upward of thirty years. Starting in 1890, his first compound was running before the World's Fair. The patent records give evidence of this early work under date of December 10, 1892. A number of engines have steadily followed each other, each involving improvements resulting from previous experience, until the essential problems have been conquered. Not only has the principle been thoroughly established, but all the important refinements have been worked out, and finally an engine embodying practically all the advances has been subjected to long continuous runs. Data almost invaluable to the art have been secured, together with a series of indicator cards and diagrams that exceed a thousand in number.

The outcome has been that the various prophecies of thoughtful engineers in the past have been more than fulfilled and there is every evidence that the heavy-duty compound combustion engine is everything that was hoped for. It is light compared with the normal Diesel, being in special cases less than one-tenth, and in some instances less than one-twentieth, in weight for the same out-

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[1] President and Engineer, The Sperry Gyroscope Co., Brooklyn, N. Y. Mem.Am.Soc.M.E.

[2] See paper by Metten and Shaw before Society of Naval Architects and Marine Engineers, May, 1921.

Abstract of a paper presented at the Annual Meeting, New York, December 5 to 9, 1921, of The American Society of Mechanical Engineers. All papers are subject to revision.

put. Its mechanical efficiency is extremely high and a distinct gain in overall efficiency from fuel to shaft has been made, as well as a very definite gain in simplicity, direct performance and smoothness of the crankshaft diagram. This has been achieved while adhering to the best practice, namely, four-cycle operation.

COMPOUNDS LIGHTER AND CHEAPER—MUCH LARGER UNITS POSSIBLE

The lightness and simplicity of the compound solves the capital-charge factor automatically. Engines of this type weighing only a fraction of the weight of the present Diesel will inevitably be found to be much less in first cost as well as in cost of upkeep.

Much higher powers than are now available are thought to be of extreme importance and much interest is centered upon the question; in fact, the more advanced among the Diesel builders are today concentrating upon ways and means to attain still higher powers from a single cylinder working on its present cycle. Of course this will increase instead of decrease the weight per horsepower. It is to the compound that we must look for a solution of this problem, for the reason that within present cylinder and cylinder-wall limitations, powers in excess of 10,000 hp. per engine are entirely practicable and are accompanied by all of the proportionate

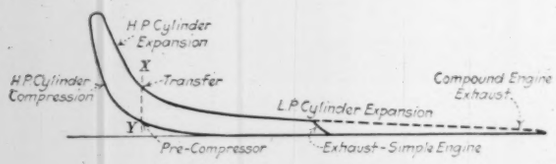

FIG. 2 INDICATOR CARD OF DIESEL ENGINE

savings in weight, space and capital charge that have been pointed out.

Our own Government has watched the progress of this work for a number of years, inspected the development in its various stages, and has come forward with orders for an initial engine which, together with orders from other sources, is now under construction. To illustrate to what low figures the compound principle can be relied upon to bring the heavy-oil engine, it should be stated that among these orders is one now under construction to weigh about five pounds to the brake horsepower. This may be looked upon as extreme, but the designed weights and finished parts as they now stand are below this figure. This brings us within striking distance of aviation engines, where the fire risk through the presence of gasoline and the electric ignition system constitutes one of the greatest menaces to aviation progress. The remarkably high mean effective pressures of the heavy-oil compound will give us the aviation engine and entirely eliminate both these sources of fire risk.

The reason for the great weight in all classes of Diesel engines is apparent when it is understood that they are designed around an extremely small quantity of air and oxygen at each stroke, an amount so minute as to be quite surprising when compared to the ponderous engine itself. The volume of the power gases available to do work is limited to the size of the combustion space, and when it is remembered that this is confined to a small crevice in the end of the cylinder of the order of one-twentieth of the travel of the piston, the limitation is at once seen. Attempts to make it larger produce both compression and ignition temperatures that are too low and we have semi-Diesel and surface-ignition engines confined to smaller sizes with tendencies to a lower grade of performance. Such engines are difficult to start and represent no gain in weight.

Two of these volumes are sometimes combined as in the opposed-piston Junkers engine. The size of the combustion space, though still minute, is known to give some small advantages over the regular engine which has only one-half of this space, but has the disadvantage in common with all two-cycle engines of the fractional piston-ring support practically without lubrication on the hot bridges as the exhaust port is uncovered by the piston.

SEPARATE CYLINDERS SUITED TO PRESSURE RANGES—TWO-STAGE COMPRESSION SECURES LARGE WORKING VOLUMES

Take, for instance, the Diesel indicator card, Fig. 2. Draw the vertical line XY and it is easy to see that the expansion pressures to the left are high and should do their work in a high-pressure cylinder, whereas those to the right, especially following the dotted extension line of expansion, are definitely low pressures and should do their work in a low-pressure cylinder suitable for the purpose. This is practically all that is attempted in compounding combustion engines. The vertical line XY also divides the compression curve into two stages, low and high, the latter taking place in the combustion cylinder proper as a second stage. No compressor delivering 500 or more pounds per square inch will undertake to do so in a single stage; there would be at least two stages. The old single-stage compression is discarded in the compound and this modern method of two-stage compression is adopted.

Supercharging or compressing in two stages gives the controlling advantage in that a very much larger unit volume of gases may be handled. The clearance spaces may be many times the size of those in the Diesel, and yet it is perfectly simple to bring these large volumes up to the requisite pressure and incandescent temperatures at the instant of fuel injection.

The large volume of power gases in the combustion chamber of the compound at once solves a number of important problems, makes the light engine easy of accomplishment, and overcomes a number of other difficulties at the same time. No longer is the chilled perimeter per unit volume of gas the controlling factor, as it is in the Diesel. The chilled walls are retired into the background as the large volume asserts itself, as compared with the small crevice indicating the total volume available in the normal Diesel (shown at C in Fig. 9), where the chilled areas exposed are very large and the volume very small. At a glance it will be seen that all this is reversed completely in the large dome-shaped clearance space D in Fig. 9, where the volume has increased very much more rapidly than the perimeter. This is again vastly increased in the low-pressure cylinder, where an extremely large volume exists with still smaller ratio of chilled perimeter. Taking all of the chambers into consideration, it is found that while retaining all of the chilled walls that are necessary for proper handling of the lubrication, still a gain is made on the order of 60 per cent in the extent of these chilled walls in the compound as compared with the simple engine.

With the large clearance volume we no longer have difficulty with solid injection, nor do we have any difficulty in using a wide range of heavy fuels. It has been known for years that as soon as the oil spray encounters chilled or even red-hot walls, the efficiency drops.[1] Here the oil fog may penetrate the deep masses of hot compressed air with instantaneous effect in every direction from the spray nozzle without encountering chilled walls and instantaneous and very complete combustion results. In the compound engine the clearance volume is so large that the entire high-pressure piston displacement causes it to lose only a fraction of its pressure, thus bringing to the second stage, or low-pressure, both ample volume and pressure so that this piston (representing 6, 8 or even 10 times the area of the high-pressure) is driven to the end of its stroke with pressures still above the atmosphere.

MUCH GREATER EXPANSION, HIGHER EFFICIENCIES

In this way the engine yields an expansion ratio based on gage pressures, which instead of being 3 or 4 to 1, as in the case of the automobile engine, or about 12 to 1 as in the Diesel, can be made as high as 120 to 1, yielding a higher return and greater efficiency from the fuel because of the lower temperature of the exhaust. The great volume in the combustion space furthermore allows this space, without distortion, to extend easily out over the top of the low-pressure piston, making a most direct connection therewith through a short transfer port (see L, Fig. 9).

THE COMPOUND CYCLE

Fig. 3 shows the cycle card without fuel, taken from the high-pressure cylinder in a 10 : 1 compound. The first-stage compression enters the cylinder at point A on its out stroke with the pressure about 113 lb., giving a power stroke indicated by line A'. At point B the induction valve closes and on the in stroke the compression proper starts and rises on line B' to Diesel values at C. There being no fuel injection, the receding stroke brings the pressures down on practically the same line B' to point B (E in Figs. 5

[1] See Eng-Comdr. C. J. Hawkes' Admiralty paper: Some Experimental Work in Connection with Diesel Engines, November, 1920.

and 6). Here the transfer valve opens and the gases pass on the in stroke to the low-pressure cylinder on line D. This is the out stroke of the low-pressure, the pressures sinking to a trifle below atmosphere before the final exhaust valve opens and continues open nearly during the entire next stroke of the low-pressure piston, which is, however, never shown on this high-pressure card but on the low-pressure card, Fig. 8.

Fig. 4 is the air-pump card representing the first stage of the compression which delivers air to a small receiver, from which air is delivered during the induction stroke, on line A' of Fig. 3, which, it will be observed, is a power stroke with a high mean effective pressure, thus recovering some of the power of the pump.

Fig. 5 is the same as Fig. 3, except that fuel has been injected, and shows the regular slow Diesel burning common to all early cards of these compounds, where from point C a perfectly level line is often drawn to point C' which marks the point of "cut-off." The gases then expand on line C'' to point E, where the transfer valve opens and the gases continue to do work on the large area of the low-pressure piston, indicated by line D. The exhaust valve opens with pressures only slightly above atmosphere at point D'. The ordinary slow Diesel burning has the objection of lower efficiencies and allowing the heat to be added to the gases out nearer the exhaust end of the stroke.

Utilizing the Detonation of Fuels

Through a research extending over a year and a half or more, conditions were discovered by means of which "detonation" of the fuels may invariably be secured. This extends to a large variety, including of course the heavy fuels. While automotive engineers have adopted extreme measures, even lowering compression, "doping" fuels, etc., etc., in order to avoid the detonation, we have been working in the opposite direction. We have found that the *thermodynamic efficiency is higher in case of high detonation diagrams* than with low. Our work has been toward realizing these high efficiencies by developing instead of suppressing this high-intensity combustion. We have therefore sought to harness and utilize to the full the detonation phenomenon for the reasons and with the results outlined herein.

Fig. 6 is a typical card taken under the same conditions and the same engine as Figs. 3 and 5, exhibiting "detonation" and showing the quick burning, piling the heat up at the beginning of the stroke and as far away as possible from the exhaust end, giving also a very much truer Carnot-cycle card. All recent running of the compound engines has been in accordance with this card. One of the achievements of high-intensity combustion is better thermal efficiency and a still further reduction in the exhaust temperatures. The engine with this type of card is lifted from the old constant-pressure to the superior constant-volume performance which frees the compound from all speed limitations. The detonation characteristics, e.g., the vertical rise on the diagram, persist even at very high speeds. This card also insures operation at lower fractional powers without indication of carbon deposits.

Fig. 7 is given as showing the range of control of the peak and shape of the card at will under the same operating conditions and with the same spray nozzle.

Elimination of Losses in Transfer

In early attempts at compounding, principally layouts, it was found that prohibitive losses would occur in the transfer, due to the falling pressures while filling the low-pressure clearances. A complete solution of this is found in a special adaptation of the process of "cushioning"—closing the exhaust valve at a predetermined point before the out-stroke end, trapping a little of the hot gases and cushioning them up to the transfer pressure so the transfer valve opens under conditions of equal pressure on each side. There are practically no losses sustained in cushioning; the power of compression is returned very completely on expansion. The additional advantage is secured of preventing all erosion due to high velocities of the hot gases over the transfer seats. These seats are amply jacketed and are found to remain smooth, bright and perfectly sealed over long periods. It is incidentally found that in cushioning, the adiabatic compression of the hot gases brings with it an equality of temperatures as well as pressures, so there is neither loss in pressure nor temperature at this critical point of transfer and the efficiencies are carried at high values throughout the cycle.

Fig. 8 shows the low-pressure card, indicating the same power-pressure line D as Figs. 3, 5 and 6. On this in stroke the exhaust valve opens at D' and closes again at point G on the out stroke, giving rise to the cushioning curve H, terminating at the same pressure and really the same temperature as at E in the high-pressure cylinder.

The Transfer-Valve Problem

The point X in Fig. 2 will be recognized as being the same as point B in Fig. 3 and point E in Figs. 5 and 6. The transfer valve considered as an exhaust valve is here called upon to handle much hotter gases than ever heretofore. It must be remembered, however, that compression in the compound is by the modern two-stage method. Air is admitted to the combustion chamber under comparatively high pressure and although it is warm, yet with each

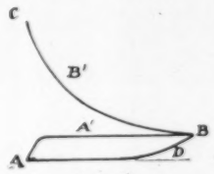

FIG.3

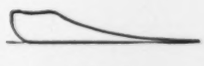
FIG 4

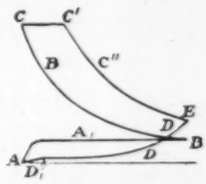

FIG.5

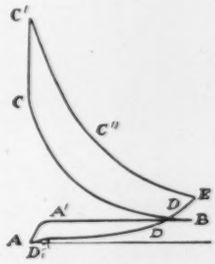

FIG.6

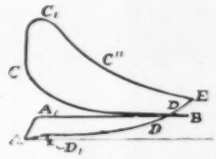

FIG.7

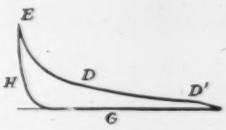

FIG.8.

FIGS. 3–8 INDICATOR CARDS OF COMPOUND CYCLE

atmosphere of pressure its cooling powers are doubled. Air at 100 lb. thus has seven times the cooling power of atmospheric air, seven times the weight and seven times the molecules in contact for cooling. In forcing the high-pressure piston down on pressure line A' in the above figures, air must pass some port in entering. Now, as a matter of fact, this port is in line with the transfer port and the induction valve itself rides on the back of the transfer valve in the form of a hollow sleeve I (Fig. 9) seated directly on the top of the transfer valve T. The back of the transfer valve is provided with greatly enlarged radiating and cooling surfaces presented to this cooling air and powerful convection currents are constantly acting when sealed. Moreover, this air when entering is at high velocity and gushes down through and bathes the deeply serrated surfaces of the back of the transfer valve, licking up the heat very completely in its inward rush.

Now in following out the cycle, it will be noticed that this is the very step that follows directly on the heels of the transfer of the hot gases (D, Fig. 3) and continues throughout the next quarter cycle (see A', Fig. 3) and through the entire descent of the high-pressure piston, which in this way delivers a real power stroke to the crank with mean effectives in some instances greater than the mean effective pressures of the ordinary Diesel, thus returning some of the power taken to drive the supercharger or first-stage pump. If the transfer valve is intensely heated on its under surface (see T, Fig. 9) and is then instantly intensely cooled on a surface five times as great, it will certainly strike and maintain a heat balance which in practice is found to be extremely low, only about one-half the

temperature of the Liberty valves, nowhere nearly approaching red heat nor the temperature of normal Diesel exhaust valves under load conditions.

Again, the heat in these gases absorbed from the hot valve is useful inasmuch as it is the auto-ignition temperatures as well as pressures that are required at the end of the compression curve B'. Here a useful heat transfer and pure regenerative process is carried out. The seats give no trouble because they are backed by the ample water jackets and, in fact, the whole transfer valve gear operates continuously and successfully and is found to be in perfect condition after hundreds and even thousands of hours of operation.

How Lightness is Obtained in the Compound Engine

The question often asked is, To just what is due to smallness and lightness of the compound engine? It is this: In the four-cycle Diesel we have the tonnage of metal due to the presence of high pressures operating at a ridiculously low material efficiency

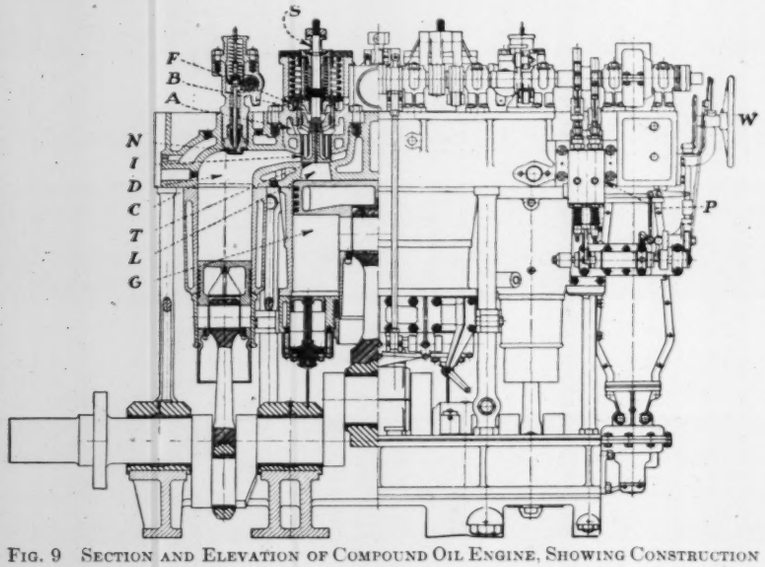

FIG. 9 SECTION AND ELEVATION OF COMPOUND OIL ENGINE, SHOWING CONSTRUCTION

because these high pressures persist only about $2\frac{1}{2}$ per cent of the total time. The Diesel card rises abruptly and immediately falls. All the rest of the time, over 95 per cent, either low pressures or no pressures at all are present, whereas in the compound the pressures *persist* and we are dealing with great blocks of power, as can be seen from the power curve C''. Although the pressures are not materially higher than in Diesel practice, they are made to persist practically clear across the card, producing a very large gross mean effective. This is instantly followed by another line clear across the card, again producing another large gross mean effective in the low-pressure cylinder when referred to the high-pressure area, all from a single fuel injection. Instead of 60 to 70 lb. net mean effective to the crank, delivering its power through a few degrees only of one stroke in four, in the compound we have two net mean effectives, each of 300 or 400 lb. per sq. in., succeeding each other and covering two strokes out of the four from a single fuel injection, giving very much better crank-effort distribution for power purposes. The point of paramount interest is that these two large blocks of power are secured *not by any material increase of pressures*, but by using large quantities of power gases, and "hanging on" to the pressures we have in those gases throughout practically two complete strokes, clear across the card twice, thus abstracting much more of the power they contain before exhausting. Suppose these to be 330 lb. per sq. in. each. Added they make 660, which is easily ten times 62 lb., a net mean effective not infrequently met with in ordinary Diesels. In an engine of simple construction giving ten times the net mean effective to its crankshaft and well distributed, there should be no good reason why it should weigh more than one-tenth the weight of the present Diesel.

The power gases work in the Diesel about 120 deg. of arc and in the compound 315 deg., or 2.6 times as long; or, considering the points of "cut-off" in each, the true expansion curve is $3\frac{1}{3}$ times as long, which accounts for its large mean effectives and higher economies.

Proper Ratio for Compounds

As to the proper ratio for compounds, engines of 10 : 1 ratio of low-pressure to high-pressure cylinder areas, also 8 : 1 and 6 : 1 have been made, operated and studied, the smaller ratios being at present considered more desirable. The weight factor does not change materially with changes in ratio in this region. The low-pressure piston operates two-cycle. The power distribution and the weight of the reciprocating parts both equalize best at about 6 : 1. This makes a perfectly balanced unit, the end masses equaling and also moving oppositely to the central. The two full power impulses following each fuel injection are also about equal. Thus full *four-cylinder performance* is secured with only three cranks and two extra power impulses are delivered on the induction stroke (see line A', Fig. 3), making six power impulses for each cycle.

Another unusual advance should be noted, viz., complete reversibility and self air starting are secured without additional valves or cams over the simple, one-way engine without air starting, there being no difference in this regard. Again comparing the full-reversing, air-starting compound unit with a similar four-cylinder Diesel of any prominent make, delivering the same number of primary power impulses to the crank, the latter has 16 valves and 32 cams. The former operates the same cycle with two extra power impulses over the Diesel with 5 cams driving 7 valves.

Doing away with the three-stage air injection pump, its intercoolers and general complexity is another important simplification. One United States builder stated recently that an excess of 11 per cent of the entire power of the engine is absorbed for driving these pumps.

Marine Type of Compound Engine

Fig. 1 shows a 10 : 1 compound engine built for heavy duty. Although this is a small marine type with high-pressure cylinders 7 in. by 11 in. running at 400 r.p.m., yet the size of the crank-pitman end in the lower center of the engine reveals the ruggedness of these parts. The fuel pumps are also shown here and the connection to the governor. The camshaft is on a shelf at the top of the engine to one side and is driven by skew gears. The electric generator forming the full load of this engine is shown in the background and one of the transfer valves with its bonnet cover stands on the floor in front of the engine. The comparatively small size of the engine, although in the foreground, is notable and stands out in marked contrast with the engine of Fig. 10, the product of the largest Diesel builder. This is the standard marine engine for some seventy ships. The electric generator forming the full load of this engine (so marked) is also in the background, as in Fig. 1. The generators in the two cases of course being standard, give an unusually excellent basis of comparison. The compound works at a piston speed of about 700 feet per minute and its generator would be still smaller in comparison, should it be worked at the piston speed of about 900 feet per minute of the large engine. Incidentally, in the foreground of Fig. 10 there is also an excellent illustration of the three-stage, intercooled, high-compression air pump for spraying the fuel into the cylinders.

The large size and weight in the Diesels extends to all makes in somewhat different degrees. A line of Diesels made in the United States are reported to weigh 512 lb. per b.hp. The engine of Fig. 10 weighs 450 lb. per b.hp., while the compound in Fig. 1 weighs less than 30 lb. per b.hp.

Internal Construction of the Compound

Now as to the construction of the compound, Fig. 9 shows an elevation to the right of the center, and longitudinal section to the left, of the engine shown in Fig. 1. The two high-pressure or combustion pistons on their out stroke are at the ends and in the center the low-pressure at its extreme in stroke. The sturdy construction is indicated by the size of the crankshaft, about 50 per cent larger than in any other combustion engine of which the author has knowledge, approaching, as it does, the bore of the combustion cylinders

themselves. The fuel pumps P and the control and manipulating wheel W are shown in elevation to the right. To the left the large dome of clearance D, forming the combustion chamber of the compound, stands out in marked contrast to standard Diesel practice, which is shown by the little space C between the solid horizontal line at the base of the clearance and the dotted horizontal line just above. The dome is large and forms an upward extension of the combustion cylinder, extending also to the right in a large sweep surrounding the transfer valve T which seals the transfer port L. The sleeve-like induction valve I is shown seated on top of the transfer valve and is controlled by the cam-operated fork F. The transfer valve and sleeve are lifted by a fork not shown, located in thimble S near the top of the stem. The first-stage annular compression pump G surrounding the trunk piston below the low-pressure piston proper, delivers its air to a small receiver, which in turn discharges to the cored port A surrounding the induction sleeve I, the cooling action of which has been described. The little balancing cylinder B sustains a permanent connection with the low-pressure cylinder. The solid-fuel injection valve and nozzle N are placed approximately over the center of gravity of the large masses of air in the clearance dome D.

The comparison with the large dome constituting the clearance and combustion space in this compound with the small distance between the solid horizontal line at the base of the combustion space in Fig. 9 and the dotted line indicating the combustion space C in the normal Diesel, is simple to make and is significant.

It is understood that the two high-pressure cylinders are operating four-cycle, one 360 deg. back of the other, discharging alternately into the low-pressure, which therefore works two-cycle and delivers power on each down stroke. The cycle has been pointed out and the general operation will be apparent from this figure.

Field of Usefulness of the New Prime Mover

To engineers versed in the problems of selecting and designing prime movers, the advantages of the compound combustion engine are readily apparent. Its light weight for a given power with resulting low first cost and capital charge, the low costs for foundations, the high speeds with consequent low costs for connected generators, the small space required and the simplicity and economy of operation are important reasons for suggesting new fields for this prime mover, which has been proven of practical value in a long series of tests under working conditions. The compound engine is especially adapted for use for auxiliary or stand-by service in water-power stations or for carrying the peak loads in central stations where installations as large as 21,000 kva. have been contemplated. The important considerations are quick starting, non-deterioration of fuel reserve and flexibility of required fuel, amounting to almost complete independence of fuel quality. Other uses for the compound which readily suggest themselves are city water works and irrigation projects, either directly or by electrical distribution.

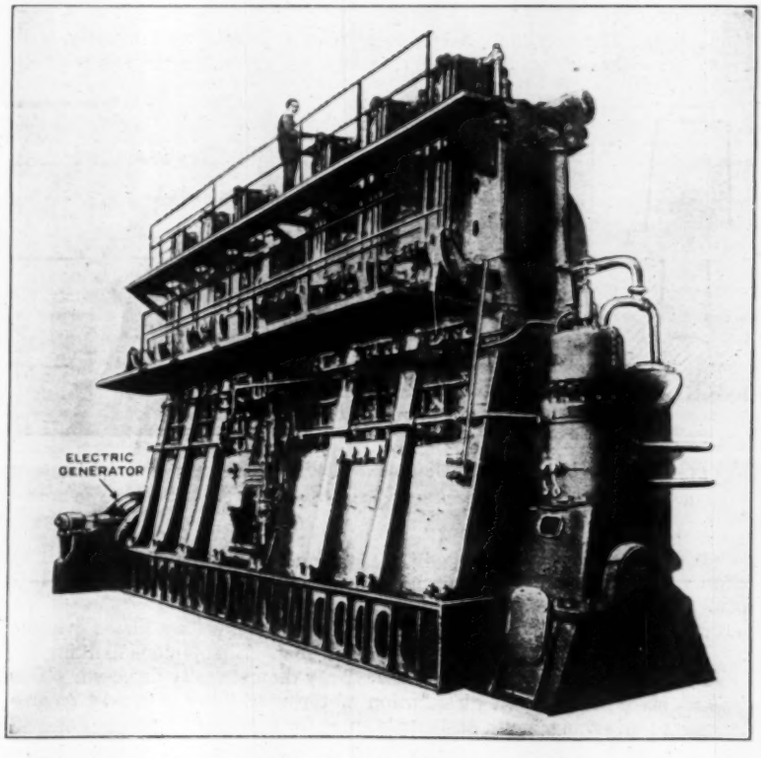

Fig. 10 Standard Marine-Type Diesel Engine

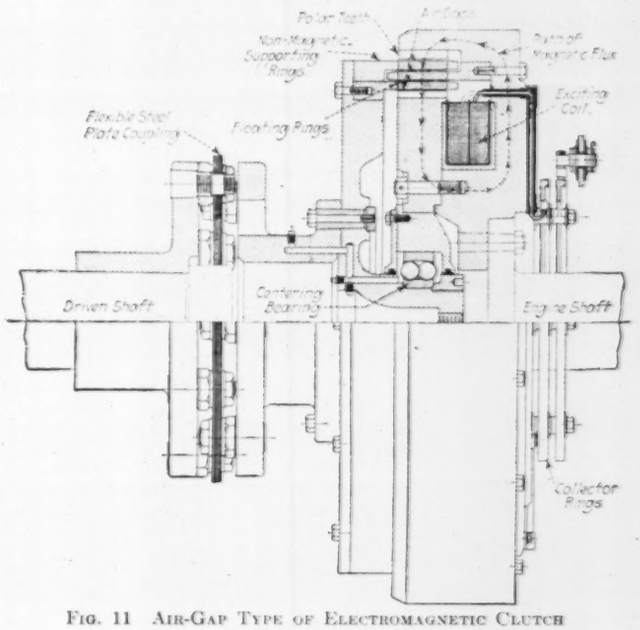

Fig. 11 Air-Gap Type of Electromagnetic Clutch

The possibilities of the compound-Diesel-electric locomotive should not be overlooked, as it presents all the well-recognized advantages of electric traction. At the same time it represents a component part of the central power station, with the advantage over the latter that it operates at the highest thermal efficiencies known—nearly three times the efficiency of even a very large power plant, i.e., three times the tractive effort is delivered to the rail from every pound of fuel burned. Also the capital charges for main feeders, substations, bonded rails and shunted switches and frogs, and the third rail or elaborate overhead construction are eliminated. The tracks are used exactly as they now stand.

Application to Ship Propulsion

We now come to the greatest present employment of oil engines, namely, their substitution for steam in ship propulsion. The advantages of motorships are rapidly being recognized, and they are now being built in practically every maritime country more rapidly than ever before. There were building last year 454,502 tons of Diesel-driven ships, or over 7 per cent of the world's total under construction. In the light of the past ten years' experience the Diesel engine has proved an efficient, reliable and thoroughly seaworthy prime mover, suitable for a large proportion of the total sea-borne tonnage.

Novel Electromagnetic Clutch Affords Elastic Drive

In connection with the development of the compound engine for marine purposes, and in order to provide any Diesel type of engine with speed flexibility equaling the reciprocating steam engine, there has been developed an electromagnetic clutch operating on an entirely new prniciple.

This new type of clutch transmits power entirely through air

gaps and has no mechanical contact whatever between the driver and driven, eliminating wear and deterioration. It is capable of remote control and can be operated at any speed from zero to full engine speed; the torque may be varied at will from maximum to minimum. The power required to operate the clutch at full load is but a small fraction of one per cent of the power transmitted. In one instance 525 hp. required 256 watts, or 0.065 per cent of the power transmitted. An outstanding feature of this clutch is that on direct drive or full speed it is magnetically locked, which insures perfect synchronism and no slip with an extreme increase in pull-out torque. At this and all times, in fact, the transmission has the "velvet touch" of an air drive and insures complete torque-wise isolation of the mass moments lying on the two sides of the clutch. As seen in Fig. 11 the clutch forms a part of even a small-sized flywheel of either a Diesel or compound with little, if any, alteration of its mass moment.

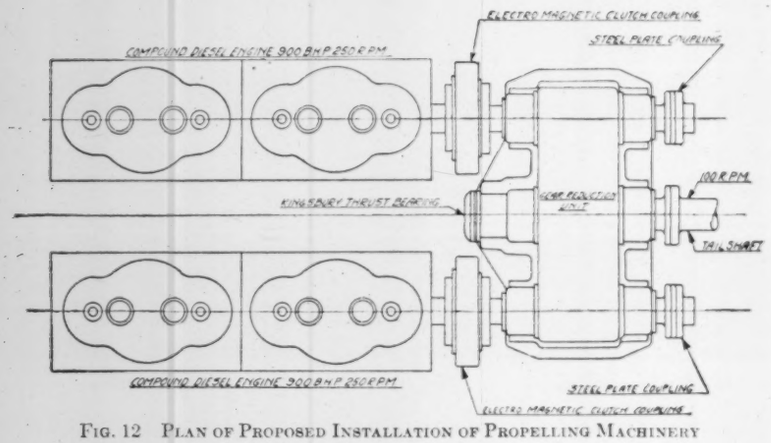

Fig. 12 Plan of Proposed Installation of Propelling Machinery

The clutch is characterized by two kinds of torque operating by opposite phenomena; the greater the differential or relative velocity between the driver and driven parts, the greater the torque available for starting and for bringing up to synchronism. This phenomenon also provides for slipping and continuous operation at all fractional speeds by means of the loaded secondary effect acting as an induction motor.

The air-gap clutch drives through magnetic flux comprising four ring elements, two of which are driving and two of which are driven. The flywheel proper accommodates an exciting coil producing the magnetic flux. At all fractional speeds or while this clutch is slipping, this magneto induction generates large currents in the driven elements which are now acting as short-circuited secondaries, producing heavy drag torques under perfect control by varying the amount of coil excitation. However, when the speed comes up in the vicinity of synchronism, locking occurs.

Proposed Installation of Propelling Machinery

Fig. 12 shows in plan view a proposed installation of the propelling machinery, securing the advantage to both engine and tail shaft of entire freedom of each to run at its own best speed. A propeller for a given ship has a speed at which it gives its most efficient performance; likewise a combustion engine can be built most economically and to give its best performance for a given size if the designer is given entire freedom to choose the best engine speed, a condition which is extremely desirable.

With this clutch and the engine combination shown in Fig. 1 several very important advantages are secured:

a There are available on a single propeller all the advantages and flexibility of a multiple engine equipment, where one engine may be shut down and completely disconnected for inspection, valve grinding, etc., and yet the ship be going forward at three-quarters its normal speed.

b Complete flexibility of the electric drive without the expense, weight and space of the electric generators and motors and the cumbersome electric control equipment for handling the heavy currents in maneuvering, and the double losses of generators and motors which are of substantial amount and a constant drag on plant and fuel economy.

c The simplest form of gear drive may be employed because the magnetic clutch allows the pinion to be a complete "floater." The pinion may thus accommodate itself to any want of precision and all sorts of idiosyncrasies of the main gear and teeth without shock. Any irregularities existing have to deal only with the small masses of the pinion itself and its stub shaft, being completely isolated from the large mass moments of the engine.

d The well-known irregularities in torque of any reciprocating engine and circumferential oscillation are entirely smoothed out by the air gap in the clutch and are not permitted to reach the pinion; its specific tooth operation is thus completely safeguarded. The crash and general irregularities of the engine torques thus never reach the pinion and therefore can have no effect on the complete smoothness of its performance.

e The torque, being under complete control, can be lowered so as to safeguard the equipment against overloading, especially when sailing in obstructed harbors, near derelicts, and where floating obstacles are likely to be encountered by the propeller blades, thus providing an important emergency disconnecting gear breaking away from the large engine masses and allowing the propeller to "stop in its tracks" through the self-interruptibility of the magnetic clutch when reduced to fractional underload condition. In this way many disasters to the propelling machinery and interruptions to the service may be avoided.

f Nearly all revolving machinery is subject to periods, sometimes running into severe "criticals." These criticals always develop from the irregularities in torque of the mass moments within the engine pitted against outside mass moments aft. This can occur only when these are solidly coupled with each other, but if instead they are isolated, as by the cushion or air gap of a magnetic clutch of proper design, these troublesome criticals with their excessive stresses are completely suppressed and can never develop.

g The combustion engine is reversible and runs equally well in either direction. The magnetic clutch solves completely all maneuvering problems, and in this way stands out in bold contrast to the difficult maneuvering and reversing conditions introduced by the non-reversible turbine.

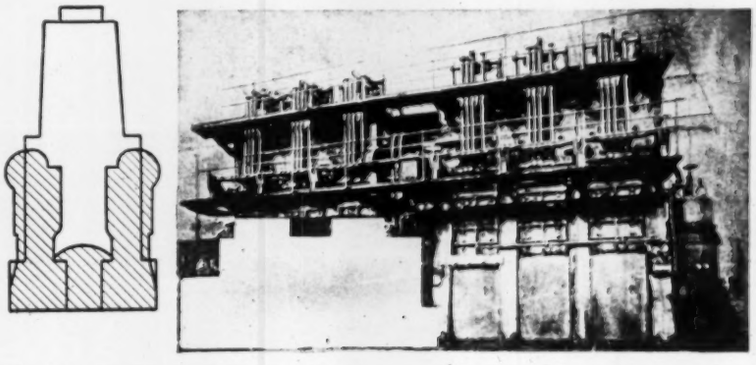

Fig. 13 Comparison between Compound Divided-Unit Geared Drive and Standard Diesel Engine Delivering to Tail Shaft the Same Power and Speed

As seen in Fig. 12, a Kingsbury or equivalent thrust bearing may be located forward of the main gear. The pinions flanking the gear on either side are not necessarily diametrically disposed. This gives an excellent distribution of the machinery, compact engine-room arrangement, and ample space for the small oil-engine generating sets for the ship, which incidentally also supply the clutches with the very trifling amount of energy and any other auxiliaries outboard of the engines. The engines are completely reversing and self-air starting, and either engine may be completely isolated at will. When either engine is running, the other may be gradually or quickly started up by means of the clutch instead of by air, if desired. The engines under this arrangement run with extreme smoothness and

(Continued on page 74)

Commercial Operation of Airplanes

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In order that those interested in the operation of airplanes for commercial use may have an idea of what may be expected of a properly organized and operated service, the author presents in this paper an analysis of the record of the Air Mail Service of the United States Post Office Department for the year ending Sept. 30, 1921. The operating record, the cost of operation, and the life and maintenance of planes and of engines furnish a basis upon which the author points out possible improvements, the most important in present practice being the use of efficient commercial planes equipped with a thoroughly reliable power plant. In regard to cost of operation, the author states that the total operating cost should not exceed 70 cents per plane-mile for single-engine planes of not over 400 hp.

IT IS the purpose of the author to present in this paper some information which may be found useful by those interested in the operation of airplanes as vehicles of transportation for profit.

Up to the present time there has been comparatively little such commercial service in this country and consequently there have been very few data developed which might be useful in an investigation and analysis of this important subject.

Commercial flying in Europe is developing very fast, but the conditions under which it is performed make it difficult to apply the information gained to operations in this country. A large part of the foreign service is devoted to carrying passengers and the operations are in many cases partly supported by government subsidies, and nearly all of the elements of cost are such as to make it difficult to apply the results to any proposed operation in the United States.

Fortunately, however, there has been a service in operation in the United States since May 15, 1918, which has rapidly developed into what may be properly characterized as the largest commercial operation of airplanes in the world; namely, the Air Mail Service operated by the Post Office Department of the United States Government.

This service is operated by a purely civilian personnel and is very similar in nearly all respects to that which would be effective in a purely commercial service. Moreover, the records of this service have been carefully kept during its entire existence, and if properly interpreted can be used as a basis for estimating the probable performance and costs of any commercial service of the immediate future.

Organization

The Transcontinental Air Mail Service operates daily in each direction between New York and San Francisco, an air-line distance of 2630 miles and a total daily mileage of 5260 miles. The various flying fields and the principal buildings located on each are as follows:

New York (Hazelhurst).	1 Hangar	Iowa City, Ia.	1 Office; stock room and repair building
	1 Storage hangar		1 Tent hangar
	1 Office building		
Bellefonte, Pa.	1 Hangar	Omaha, Neb.	1 Hangar
Cleveland, Ohio	1 Hangar	North Platte, Neb.	1 Hangar
	1 Workshop	Cheyenne, Wyo.	1 Hangar
	1 Office	Rock Springs, Wyo.	1 Tent hangar
Bryan, Ohio	1 Hangar	Salt Lake City, Utah.	1 Hangar
Chicago, Ill.	1 Large repair hangar	Elko, Nev.	1 Tent hangar
	1 Storage hangar	Reno, Nev.	1 Hangar
	1 Operating hangar	San Francisco, Cal.	1 Hangar
	1 Office		1 Office
	1 Stock house		
	1 Test house with stands		
	1 Oil house		

The airplane equipment now used in this service has been standardized and all machines are the De Haviland planes equipped with Liberty 12 engines turned over to the Mail Service by the War and Navy Departments. These machines are rebuilt to accommodate the mail load in the cockpit in front of the pilot and strengthened to meet the hard service required. A considerable amount of this equipment was turned over as indicated, and is stored in two buildings in Newark, N. J. This constitutes the major source of supplies for the entire service.

The total investment of the Air Mail Service is about $800,000, of which $133,000 is for buildings, trucks, tools, etc., the remainder being for airplanes and engines.

Equipment

It is obvious that the actual number of planes in serviceable condition and under repair may vary from day to day, but the following is a fair average figure for the year: In serviceable condition, 50; under repair, 18; awaiting repair, 30. During the year, 27 planes were damaged beyond repair and salvaged, while 48 new planes were placed in service and about 20 experimental types retired.

Engine equipment has always been in excess of actual need, because of the large number of Liberty engines turned over by the Army. The total number of Liberty 12A (Army high-compression) and Liberty 12N (Navy low-compression), developing about 400 and 350 hp., respectively, in use is about as follows: Engines in serviceable condition, in planes and as spares, 150; engines under and awaiting repair, 350. The foregoing figures do not represent the engine requirements for such a service.

An accurate estimate of the total engine requirements for this service can be based on the following: 22 engines are required for the 22 planes in daily service; at least 1 spare engine should be at each major station, making a total of 14; another supply of approximately 30 engines is necessary for those constantly in transit between the various fields and the overhaul stations, including the period of overhaul, making a total of 66 engines. If this service is properly organized a total of 75 engines is ample for successful operation of such a service.

Operating Record

The operating record for the past year is shown in Table 1. For a thorough understanding of these figures it is thought well to briefly outline the conditions under which the service was rendered.

The transcontinental course is divided into 13 legs of approximately 200 miles each with stations as given above. The route is divided into three major divisions—the eastern, extending from New York to Chicago, the central, from Chicago to Rock Springs, Wyo., and the western, from Rock Springs to San Francisco, Cal. It has been found that in the western trip the flight is hampered by prevailing westerly head winds, whereas the eastern trip is, of course, assisted by such conditions. Inasmuch as the supply of gas for each ship is approximately only four hours at cruising speed, it becomes necessary in many flights to stop at intermediate stations for service. Many times coming east, planes fly a major leg of approximately 400 miles. The number of such trips per month is somewhat varied, depending upon conditions.

While the available space in each plane accommodates 400 lb. of mail, the average amount carried per trip for the entire year was less than 150 lb. per plane per trip. These planes carry a pilot only, who flies a leg in one direction each day, returning to his home station the next day and laying off the third day. This schedule is, of course, subject to change, which occasionally results in a pilot doing more mileage than indicated.

The total flying time per day varies with the weather conditions, but the average speed for the entire year was 86.3 miles per hour; for the last 6 months (during better weather conditions) the average speed was 87.88 miles per hour. Up to the present time all flights have been made during the day. An indication of what is possible in a continuous trip, is the record established on Feb. 22 and 23, when the mail was carried from San Francisco to New York in elapsed time of 33 hr. 20 min., or a total flying time of 26 hr. 50 min. The fastest scheduled train time between these two

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points is 92 hr. The eastbound trip from Chicago to New York has been made in 5 hr. 30 min. The flight from Salt Lake City to San Francisco was made on Oct. 14, 1921, in 6 hr. 1 min. elapsed time, or a total flying time of 5 hr. 32 min. over a distance of 624 miles. The fastest train between these two points is scheduled for 24 hr. 15 min. It follows that, for the transcontinental distance, daylight flying only will cut train time about in half, and with night flying, the time is cut to about one third.

The operation record discloses one feature of special merit given under "Per Cent of Performance." It will be noted that the percentage of performance for the year was 88.33 per cent. For the last 6 months this average was 98 per cent, of which 96 per cent was actually completed on scheduled time. In view of the fact that the Pennsylvania Railroad in their printed timetables boasts of a train performance of 95.6 per cent on time, the foregoing record for the last 6 months is truly remarkable.

As to the effect of weather on the service, it will be noted that defaulted trips and the number of forced landings show a decided increase during the winter months. An interesting fact is that the number of forced landings from mechanical trouble also shows an increase, which would indicate the effect of cold weather on the quality of work done by mechanics.

During the year ten pilots and one mechanic were killed—four of the former during the last six months. This is equivalent to one pilot killed for each 169,756 miles flown.

During the year 27 planes were so badly wrecked that they were salvaged instead of repaired, and there were 145 forced landings which resulted in damage to planes necessitating repair work; of these about 100 required major repairs. Obviously some were damaged more than once during the year. A further analysis of this as affecting the cost of operation is given later.

The large number of actual forced landings from mechanical trouble and other causes will no doubt attract attention as being excessive, and it should be noted that of the total number of forced landings only 172 resulted in damage to the planes. This is one plane damaged for every 10 forced landings.

It should, in fairness, be pointed out that all landings other than those regularly scheduled, even though made on an intermediate Air Mail field, are counted as forced landings.

Cost of Operation

The consolidated costs of operating this service for the yearly period chosen are shown in Table 2. It will be noted that there is no charge for interest on investment. This is of course a proper charge in any commercial service and should be added in any estimated costs. By making such a charge and adding it to the total costs shown in the table, it is thought that the figures resulting are safe and conservative for estimating the operating costs for any similar commercial line. In fact, the figures shown can be very much bettered if advantage is taken of the experience gained in the Mail Service.

An analysis and consolidation of the figures given in this table are shown in Table 3, which give the service and unit costs and the costs per mile for the year. In this table the total costs are divided into three general headings, namely, Overhead, Flying and Maintenance. Under the head of Overhead is included departmental overhead, office force and watchmen, motorcycles and trucks, rent, light, fuel, power, telephone, water and radio. Maintenance consists of miscellaneous, mechanics, helpers, repairs and accessories, and warehouse charges. Flying consists of gasoline, grease and oil, and pilots.

It will be noted that the mileages as shown in column 9, Table 1 and in column 3, Table 3, do not agree. The former figure is miles traveled in regular mail trips and the latter is "total miles" flown, which includes ferry trips, test flights and retrieving planes. The "total miles" is the proper basis for estimating costs per mile.

An examination of Table 2 will show that the largest items of cost are gasoline (15.0 per cent of the total), repairs and accessories (18.6 per cent), pilots (12.8 per cent) and mechanics and helpers (14.5 per cent). Considering these separately, it is seen

TABLE 1 OPERATING RECORD OF THE U. S. AIR MAIL SERVICE, OCT., 1920—SEPT., 1921

Month	Trips Possible (Scheduled)	Trips Attempted	Trips Defaulted	Trips Uncompleted	Weather Encountered		Mileage Possible	Miles Travelled	Per Cent of Performance[1]	Mail Carried, Lb.	Forced Landings Due to	
					Trips in fog	Trips clear					Mech.	Other
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1920												
October	750	593	157	57	190	143	154,700	123,274	79 68	89,541	54	59
November	758	575	183	77	230	345	156,076	114,750	73 50	87,302	85	69
December	884	662	222	105	347	315	178,776	127,306	71 21	89,942	89	138
1921												
January	850	697	153	87	253	444	171,900	132,679	77 18	84,435	117	131
February	782	660	122	71	310	350	159,238	130,431	81 90	88,135	82	122
March	918	871	47	59	351	520	185,652	171,593	92 42	110,117	64	123
April	884	837	47	36	370	467	178,776	171,156	95 73	117,778	79	107
May [2]	850	833	17	20	320	513	171,900	168,397	97 96	115,073	72	81
June [3]	832	829	3	10	268	561	168,636	166,956	99 00	105,838	57	51
July	624	623	1	6	65	558	131,450	130,555	99 31	77,276	34	29
August	693	689	4	13	129	560	136,974	134,549	98 22	84,680	32	30
September	657	651	6	8	180	471	127,706	125,914	98 59	88,401	13	26
Total	9482	8520	962	549	3013	5247	1,921,784	1,697,560	88 33	1,138,518	778	966

[1] For last 6 months, 98 per cent.
[2] May 31 — Last day's service on New York-Washington Route.
[3] June 30 — Last day's service on St. Louis-Twin Cities Division.

that the gasoline cost cannot be materially reduced by the use of more economical engines, for even if engine economy is increased, say, 10 per cent (which is difficult), the total reduction would only be one tenth of 15 per cent, or 1.5 per cent of the total.

The largest item, repairs and accessories (column 4), is susceptible of considerable reduction. The elimination of forced landings and the damage resulting therefrom would largely reduce this charge. Fair wear and tear on places is relatively very small.

The basis on which pilots are paid, namely $2000 per annum, plus 5, 6, and 7 cents per mile flown, has proved to be very satisfactory, and more so than any other basis tried by the Mail Service. In all cases it supplies the men with a living wage and develops efficient service, which is rewarded by increased pay.

The pay for chief mechanics in the Mail Service averages $2000 per annum; other mechanics from $1400 to $1800 per annum; helpers from $1100 to $1400 per annum; and watchman and helpers from $900 to $1200 per annum.

An explanation of column 7 is essential. In most of the major fields the Mail Service was supplied with flying field, and in some cases with hangar facilities, by the cities in which they are located, without charge therefor. Rent for field and hangar facilities is paid at New York, Bellefonte, Pa., Cleveland, Ohio, Bryan, Ohio, Chicago, Illinois, and College Park, Maryland (training station). At all other cities west of Chicago no rent is paid.

This item of cost is therefore comparatively low and should be modified if used for estimating similar costs of a commercial line, unless similar arrangements could be made with various municipalities for use of municipal airdromes. If commercial companies have to purchase flying fields, as well as field equipment, it would of course, add largely to the capital costs, as well as the operating charges. It is believed, however, that very favorable arrangements can be made with most of the large cities in the United States for proper landing-field facilities.

The analysis shows that the average yearly operating cost per flying mile was 80.66 cents and for the last six months of the year, 71.83 cents.

As mentioned herein, if the cost is reduced to a ton-mile basis, the figures resulting will be unreliable; a fair basis of comparison is on a plane-mile basis, for it costs but little more to fly a plane loaded to its capacity than it does to fly it empty. It is a safe statement that under the conditions prevailing in the Mail Service, the cost per plane-mile will soon be reduced to the neighborhood of 60 cents.

With proper equipment and organization, a commercial service, using single-engine planes of not over 400 hp. each and flying only one round trip per day over a distance equivalent to that of the transcontinental service, can be accomplished for a total cost not exceeding 50 cents per flying mile. This is especially true if more than one round trip per day is flown.

TABLE 2 CONSOLIDATED COSTS OF OPERATING U. S. AIR MAIL SERVICE FOR YEAR ENDING OCT. 1, 1921

Month	Gasoline	Grease and oil	Repairs and accessories	Miscellaneous	Motorcycles and trucks	Rent, light, fuel, power, telephone and water	Office force and watchmen	Warehouse	Pilots	Mechanics and helpers	Radio	Departmental overhead charge	Total
October, 1920	$20,959.94	$3,840.85	$22,571.32	$16,264.81	$5,827.95	$1,813.91	$8,501.34	.....	$10,989.85	$21,204.47	.....	$5,448.06	$117,422.50
November	17,635.97	3,920.24	18,626.50	16,511.32	5,197.57	2,511.17	9,081.01	.....	16,460.01	19,510.24	.....	6,289.69	115,743.72
December	17,783.40	3,814.04	21,072.46	21,529.14	5,190.62	2,954.73	12,310.29	.....	15,816.07	20,564.00	.....	4,031.01	125,084.76
January, 1921	18,558.44	4,303.29	28,006.76	18,790.86	6,010.07	3,405.32	12,136.21	.....	15,432.13	19,583.76	.....	3,880.59	130,107.43
February	18,823.70	3,824.18	17,689.41	20,464.60	6,581.91	3,904.82	12,025.41	.....	16,246.74	18,388.37	4,744.81	3,775.30	126,469.25
March	22,896.17	4,970.33	33,531.52	17,827.86	6,832.30	3,792.54	11,270.34	.....	17,851.24	19,912.92	4,583.10	3,725.75	147,194.07
April	22,956.61	5,554.75	31,321.32	12,829.73	6,457.85	2,559.12	12,254.29	4,277.72	17,965.49	18,577.71	9,834.41	3,301.64	147,890.64
July	21,752.41	4,870.72	15,217.83	10,551.05	5,666.64	2,277.41	11,868.01	4,484.67	17,708.11	16,595.44	11,184.21	3,578.24	125,754.74
June	19,624.08	4,544.77	27,921.81	8,236.00	3,918.51	1,110.32	9,493.98	4,524.12	18,807.17	17,343.72	8,602.67	3,262.90	127,479.83
July	15,314.14	3,377.71	20,312.72	9,759.07	3,966.08	1,209.05	9,304.52	5,357.08	14,636.14	13,912.18	9,629.07	3,021.35	109,799.11
August	14,711.17	3,513.35	20,948.14	9,014.39	4,215.42	1,205.92	8,323.45	5,574.94	14,764.20	15,008.99	5,571.22	2,882.58	106,986.98
September	13,530.82	3,232.78	18,742.47	8,630.28	3,941.77	1,725.59	9,280.02	5,415.87	14,329.58	14,773.75	5,772.40	2,799.83	102,908.45
Totals	$224,546.85	$49,766.99	$275,962.24	$170,409.11	$63,815.69	$28,469.90	$125,818.87	$29,634.40	$191,006.73	$215,375.35	$59,921.87	$45,996.94	$1,482,921.48
Per Cent of Total Cost	15.0	3.35	18.6	11.5	4.3	1.91	8.5	2.0	12.8	14.5	4.04	3.1	

LIFE AND MAINTENANCE OF PLANES

It may be noticed that in the foregoing no account is made of depreciation. In the present service no plane has remained intact long enough to wear out and so determine even approximately a rate of depreciation. Before a plane wears out most or all of the parts are replaced and charged up under that heading, or else it is so completely destroyed as to be retired from service, charged off entirely, with credit for such material as can be salvaged for use in repairing other planes. A fairly accurate idea of the rate of this destruction may be had from the following data:

During the year 27 planes were so badly damaged that repairs were not undertaken, these planes being salvaged. Of the many forced landings, 145 resulted in "crashes" necessitating repairs, of which about 100 necessitated major repair work. The number of "crashes" is thus about 10 per cent of the total number of forced landings. The average for the year is one "crash" for each 17,560 miles flown with mail; and for the last six months, 31,211 miles.

The number of planes required as original equipment to operate such a service as the Mail Service and the rate and cost of replacement may be estimated as follows:

1 plane for each of the 22 daily flights	22
1 spare plane for each daily flight, to be used in case of "last-minute" trouble with scheduled plane	22
1 spare plane at each of the 14 fields which may be in transit to and from repair shops and under repair	14
Total	58

Mail-Service experience shows that after a plane has had about 450 hours in the air it is necessary to lay it up for a thorough inspection and reconditioning. This operation involves some labor and material (usually new wing covers, etc.) and costs an average of $600 per plane. The total time required for such an operation at present is about two months. Since the flying hours per year are 21,952, the total number of such overhauls is 21,952 ÷ 450 or 49. The record also shows that about 100 planes were so damaged as to require repairs. The average cost of these repairs was about $1000 each and the average time about two months per plane. The present rate of repair and overhaul for the entire Mail Service is about 11 to 12 planes per month.

It is thus seen that about 14 to 15 planes (about one for each 14 fields) must be constantly traveling to and from the repair shops and undergoing repairs. It should be stated that some plane repairs are made at many fields as well as at the main repair shop in Chicago.

An analysis of the above shows that:

a The initial plane equipment is about one (1) plane for each 82 miles of scheduled flight
b One (1) plane repair for each 16,975 scheduled miles flown
c One (1) plane reconditioned for each 34,000 scheduled miles flown
d One (1) complete "washout" for each 62,000 scheduled miles flown
e The cost of conditioning 49 planes at $600 each = 1.8 cents per mile
f The cost of repairing 100 planes at $1000 each = 6.0 cents per mile
g The cost of "washouts" for 27 planes at $4000 each = 6.5 cents per mile
h Total cost for repairs and replacements = 14.3 cents per mile.

This amounts to a total estimated cost of $238,000. Deducting this amount from the total in column 4 ($275,962), leaves $37,962, which it is fair to assume is the cost of engine overhauls and repairs, or about 2.25 cents per mile.

LIFE AND MAINTENANCE OF ENGINES

The record of engines actually replaced, repaired, salvaged, etc., is so involved in the records that it is difficult to discover the exact data. However, methods of maintenance, inspection and overhaul have been so developed and improved that it is more accurate to base an estimate on the present rate than to use total figures for the year.

Present methods of conditioning and caring for engines have resulted in an almost uniform service of 100 hours of running between each overhaul, unless an engine is damaged in some "crash." Since a total daily mileage with mail is about 5300 miles and the average speed is 86.3 miles per hour, the daily flying time is about 62 hours per day. To this must be added the time consumed in warming up engines (6 hours) and the time of engines on various test stands, so that the total daily time for the service is 80 engine-hours. This is equivalent to 0.8 engine replaced per day. Crashes, mechanical troubles and causes other than plain wear bring up the rate to just about 1.0 engine per flying day. While this may seem high, considering that only twenty-two planes fly regularly each day, it is not, for 100 flying hours per

engine between overhauls is a very high figure and can only be attained by the most efficient and systematic conditioning and repair methods in force in the Mail Service. While about 300 engines were used, the whole 300 were not actually overhauled, as many new engines were placed in service during this period. The yearly demand is, however, at about a rate of 300 engines per year.

This running time of 100 hours between overhauls is true even after the second and sometimes the third overhaul, the necessary replacements being made at each overhaul.

The average cost of an engine overhaul is as follows:

One mechanic and one helper, 10 days, 8 hours each	80 hours
Washing and valve grinding by other men	8 hours
Carburetor work, cleaning and adjusting	4 hours
Ignition work	4 hours
Block testing	6 hours
Total	102 hours

This total time may vary 50 per cent each way, but it is a fair average. The average labor cost is about $75 per engine. The average cost of the necessary material replacements, based on Government war prices, is $150. The average total cost is therefore $225 per engine. This cost may seem excessive, but is justified by the amount of careful and accurate work done, which is the real reason for 100 hours of further satisfactory service.

TABLE 3 ANALYSIS AND CONSOLIDATION OF FIGURES GIVEN IN TABLE 4 FOR PERIOD OCT. 1, 1920–SEPT. 30, 1921

	Service and Unit Cost					Cost Per Mile, Cents		
	Gasoline gal. (1)	Total Time, hr.-min. (2)	Total miles (3)	Cost per hour (4)	Cost per mile (5)	Overhead (6)	Flying (7)	Maintenance (8)
1920								
October	60,010	1,852-56	154,486	$66.71	$0.80	$0.18	$0.23	$0.39
November	50,573	1,651-20	139,759	73.57	0.87	0.21	0.27	0.39
December	49,844	1,569-28	131,040	83.60	1.00	0.23	0.29	0.48
1921								
January	51,427	1,668-51	139,609	81.78	0.98	0.23	0.27	0.48
February	68,698	1,733-04	153,655	76.08	0.92	0.25	0.27	0.40
March	66,929	2,103-36	186,625	73.18	0.82	0.19	0.25	0.38
April	66,854	2,175-04	186,950	67.98	0.79	0.18	0.25	0.36
May	64,322	2,041-29	181,216	61.08	0.69	0.19	0.24	0.26
June	57,873	2,148-27	185,091	59.33	0.69	0.15	0.23	0.31
July	48,625	1,644-26	148,684	66.76	0.73	0.18	0.22	0.33
August	47,818	1,696-30	149,432	63.06	0.71	0.16	0.22	0.33
September	43,953	1,667-07	148,099	61.72	0.70	0.17	0.21	0.32
Total	676,926	21,952-18	1,894,646	$69.57 Avge.	$0.808 for year	$0.1933	$0.246	$0.368

Total average for year . . 80.66 cents per mile
Avge. for last 6 months . . . $0.1716 $0.2282 $0.3182
Total Average for last 6 months 71.83 cents per mile

Average speed for the year $= \frac{\text{Col. 3}}{\text{Col. 2}} = 86.3$ miles per hour

Average speed for the last 6 months = 87.88 miles per hour

Right here may be a proper place to point out the economy resulting from such methods. More frequent overhauls and a less satisfactory service record are a sure sequel to a lack of attention to the power plant, which is *the* important element. To illustrate, consider briefly the procedure employed in the Air Mail Service. Even a new engine is not assumed to be in proper condition. Nothing is "taken for granted." The method of conditioning of such an engine, and in general all engines after repair, may be briefly described as follows:

Even new motors are at least partly torn down to inspect the condition and fit of cylinders, pistons, piston rings, crankshaft and pin bearings, gears, etc. Crankshafts are especially checked for alignment, end play and proper condition of thrust bearings. Carburetors are carefully inspected and calibrated for both mechanical perfection and proper functioning, as are also generators, distributors, and other parts. The usual procedure is to put on every engine a set of carburetors, distributors, etc., which have already been inspected and calibrated in workrooms devoted to this special work. Such similar parts removed are turned into these departments for conditioning. All gaskets, especially those at carburetor and intake-manifold connections, are replaced with those whose condition is known to be good, thus preventing possible air leaks and improper carburation. Rubber-hose connections on gas, oil and water pipes are all replaced when necessary and it is usually necessary.

By using a timing disk, the correct timing of camshafts, valves and distributors is checked and the distributors for each bank of cylinders are synchronized both mechanically and electrically to within a quarter of a degree.

After a complete inspection and conditioning, the engine is run for about two hours at speeds varying from 300 to 1400 r.p.m. and also with wide-open throttle. After test, the engine is washed with kerosene and again inspected externally, and any faults which may have developed are corrected. All nuts are tightened, if necessary, all cotter pins are placed and securely fastened and the general condition made up to a *standard* and passed by the chief mechanic.

The foregoing constitutes a presentation of the mail record for the year, together with its analysis and certain deductions from this record, based on the author's experience in and knowledge of the Air Mail Service. It is assumed that some of the lessons learned in this service, and perhaps some of the opinions as to what improvements are possible, will be interesting, and they are accordingly set forth in the following paragraphs.

Improvements Possible

First and foremost, it must be apparent that the actual pay load (or mail load) carried is very small for planes powered with 400 hp., and if the cost of operation be reduced to a ton-mile basis, the results are not encouraging. However, it must also be evident that the costs really apply to a specific number of plane-miles, and not ton-miles, for it costs almost exactly as much to fly a plane empty as it does loaded. The mail planes carried an average load throughout the year of only about 133 lb. per trip attempted. As previously mentioned, the maximum mail load possible to put into the space available in the fuselage of these converted war machines was about 400 lb. These machines are now being remodeled to carry 850 lb. of mail. The important point, however, is that in a plane designed for commercial service, using the same Liberty 12, 400-hp. engine, and *costing no more to operate*, the *pay load should be all of 2000 lb.*

Another important point to bear in mind is that the mail planes make *one* trip each way per day. A commercial service operating several trips per day could do so without greatly increased overhead costs and at a considerably reduced unit cost of service. Just what the reduction would be, would depend, of course, on the number of trips made. Hence it may be fairly said that a most apparent improvement is a use of planes designed for commercial service, those which will carry a maximum load economically over a reasonable distance at high speed.

The cruising speed of such a plane should not be much, if any, less than 100 miles per hour. Head winds of 30 to 40 miles per hour are sometimes encountered, which slow down the actual ground speed by exactly that much, which means that the 100-miles-per-hour plane is traveling at (100–40) 60 miles, whereas a plane having an air speed of 130 miles per hour, or 30 per cent more, is doing (130–40) 90 miles per hour over the ground, or 50 per cent more than the 100-mile plane. Some carrying capacity should be sacrificed to speed in order to enable a plane to make time under adverse weather conditions. High speed also decreases the time required to fly a given distance and also decreases the total gas consumption, an important consideration, as will be seen.

Inasmuch as the fuel load is one of the factors in determining the size and weight of the plane, it is important that the fuel be used as efficiently as possible. The actual cost of the fuel burned is not so important as the reduction in the total fuel weight for a given flight, for this saving in weight may be put into added cargo; or, more important, it can be put into added power-plant weight, which will, in large measure, prevent forced landings. Overall

efficiency involves (*a*) reducing plane resistance, (*b*) increasing the loading per unit of wing area, (*c*) using a propeller of the highest possible efficiency, (*d*) running the engine, or engines, at nearly full power and (*e*) using engines of high specific economy. The effect of a proper combination of the above elements is to reduce first cost by using relatively small machines to do the work of large ones, which in turn decreases capital costs and further reduces the operating expense.

The question of reducing plane resistance, that is, increasing the ratio of the lift to drag (L/D), seems to have been given serious attention only in military or racing machines and has been ignored on commercial machines, especially of the multi-engined type. As the gross load which can be carried is equal to the thrust of the propeller multiplied by the ratio of the lift to drag (L/D) at a given speed, and as a low-resistance plane does not need to weigh more than one of higher resistance, it follows that the "usefulness" will be increased by increasing the lift-drag ratio, but in much greater proportion. For example, in an airplane making 100 miles per hour with a propeller efficiency of 80 per cent, the net available thrust is 3 lb. per engine hp. If the L/D ratio of such a plane is 6 at this speed, the total weight-carrying ability is 18 lb. per hp. If the weight empty is 10 lb. per hp., the net weight of the useful load is 8 lb. per hp. By increasing the lift-drag ratio to 9 instead of 6, the total weight-carrying ability will be 27 lb. per hp., and the net useful load 17 lb. per hp. instead of 8 lb. In other words, an increase of 50 per cent in the L/D ratio increases the useful load capacity 112 per cent, a gain by no means negligible and, in fact, not difficult to obtain.

Real airplane engine efficiency is not in fuel economy alone, although a low specific fuel consumption is essential. Contrary to more or less popular ideas, reliability is not a direct function of weight per horsepower only, for the mere addition of weight does not necessarily add reliability. As a matter of fact, the designers of recognized ability agree that airplane engines should be as light as possible. Lightness is an inherent quality of airplane-engine design and does not necessarily mean decreasing the factor of safety of important members below a safe figure. Making valves (for instance) much heavier would seriously interfere with their proper functioning as valves.

The best engines have a combined fuel and oil consumption of seldom less than 0.5 lb. per hp-hr. at full load, so that fuel and oil for a 5-hour flight is 2.5 lb. per hp., or more than the weight of a modern engine. It is therefore important that the fuel be consumed efficiently.

If the desire to "take off" quickly and climb rapidly is met, there must be much more power available than is required for economical cruising, and since all present types of engines have a higher *specific* fuel consumption when throttled, it follows that best results are to be obtained by some method which permits engine speed reduction with a nearly wide-open throttle. The variable-pitch propeller for single-engine machines is one solution of the problem.

Another solution is the multiple-unit power plant; that is, two or more power units driving a single propeller.

This brings us to a most important consideration in commercial operation, viz., the prevention of forced landings. Their elimination will practically insure 100 per cent service all of the time and materially reduce the amount of the largest single item of cost, viz., that of repairs of planes and engines. Until we can fly planes from one airdrome to another with certainty, even at reduced speed, we cannot obtain the best service records nor the lowest operating costs.

The author ventures to predict that the next most successful departure from a single-engine machine will be the multiple-unit plant using a single propeller. And further, that such a power plant will not consist of separate complete engines geared to one "stick," but perhaps of two, three, or even more, banks of cylinders on a common crankcase, which will also house the necessary shafts, gears and clutches in this rigid structure. All the units of such a power plant could be used in "taking off" and climbing to a safe altitude, after which one or more could be shut down and held in reserve to be put into service if required. Engine and propeller speeds in such a unit could be made such as to give maximum combined efficiency under normal operating conditions. The weight of fuel saved in such an efficient combination, over a reasonable length of flight, will compensate for the added weight of the "relay" units of such a power plant.

The experience of the Mail Service, as well as that of others, is that a landing chassis of ample strength saves many a "crash" in a forced landing, as well as in a hard landing on the flying field. If the landing gear stays together, much damage is averted, which otherwise might be serious. Large wheels and large tires have proved to be most useful, especially in rough and soft ground. In fact, the Mail Service uses Handley-Page bomber wheels on the DH4 machines as standard equipment and has operated them on soft fields, which would have been impossible with standard DH4 wheels and tires. Nor did these larger tires and wheels slow down speed to any noticeable extent. There seems to be almost no reasonable limit to the size of wheels which may advantageously be used.

In a large number of forced landings, where damage results, the front end of the machine only suffers, such as the propeller and the radiator and possibly the front end of the fuselage when the plane "noses over." This necessitates laying up the whole plane during the repair operation. To obviate this, some designers are using a separate quick-detachable nose, which carries the engine. The advantages of such construction are too obvious to warrant discussion.

It will no doubt be found desirable in commercial machines to use unit construction as much as possible, so that replacements may be quickly made and the damaged unit repaired at leisure.

Intelligent engineering attention to the many details of airplane design will be well repaid in more efficient operation and decreased cost. We do not need to seek for new or radical types with which to run a commercial service. The present types, properly engined, will deliver a most satisfactory service if handled by a properly organized and operated personnel.

Some idea of what a commercial plane, using a 400-hp. engine, can do, is given in the following data, which are based on accurate knowledge of proved performance. Such a plane having a lift-drift radio of 9, will not weigh over 5 lb. per sq. ft. of wing area. Besides fuel and oil for a 4-hour flight, together with a pilot and other accessories, such a plane will carry an actual pay load of 3000 lb. at a cruising speed of 100 miles per hour with the engine throttled down so as to be developing only two-thirds of its maximum 400 hp. Such a plane will cost no more to operate than the mail planes discussed herein.

CONCLUSIONS

While both the design and operating methods are susceptible of improvement, it is believed that the following are warranted from our present knowledge and experience:

a The number of planes required for a given service is about one (1) for each 100 miles of scheduled flight

b The number of spare engines required is about 50 per cent of the total number of planes

c The total operating cost should not exceed 70 cents per plane-mile for single-engine planes of not over 400 hp.

d Scheduled flights over reasonably long distances can be at least twice as fast as the fastest scheduled trains, flying in daylight only, and at least three times as fast if night flying is done

e Night flying can be successfully accomplished with reliable power plants and a proper equipment of airdrome beacons and landing flares

f The most important and desirable improvement in present practice are: the use of efficient commercial planes equipped with a thoroughly reliable power plant

g The United States is admirably adapted to commercial airplane service because: (1) the large area permits long flying distances; (2) large centers of population well distributed over this area should supply ample business, and, (3) fast transportation of both goods and passengers is more in demand than in any other country in the world

h The development of a large commercial service will furnish a reserve of planes, pilots, mechanics and other highly skilled men which would undoubtedly be the most valuable and effective part of our national defense.

Process Charts and Their Place in Management

By FRANK B. GILBRETH[1] and L. M. GILBRETH, MONTCLAIR, N. J.

The process chart is a device for visualizing a process as a means of improving it. Every detail of a process is more or less affected by every other detail; therefore the entire process must be presented in such form that it can be visualized all at once before any changes are made in any of its subdivisions. In any subdivision of the process under examination, any changes made without due consideration of all the decisions and all the motions that precede and follow that subdivision will often be found unsuited to the ultimate plan of operation.

In this paper the authors point out the place of the process chart in management and present established working data used successfully in numerous working installations for many years. They also point out its simplicity, field of application, its relation to standardization, etc., etc.

While the process-chart methods will be found helpful in any kind of work and under all forms of management, the best results can come, the authors state, only where there is a mechanism of management that will enforce and make repetitive the conditions of the standards.

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The process chart is a record of present conditions. It presents, in simple, easily understood, compact form, data which must be collected and examined before any improvement in existing conditions and methods is undertaken. Even if existing conditions are apparently satisfactory, the chart is useful as presenting much information in condensed form.

The process chart serves as an indicator of profitable changes. It assists in preventing "inventing downward," and stimulates invention that is cumulative and of permanent value. It is not only the first step in visualizing the *one best way to do work*, but is useful in every stage of deriving it.

This paper presents established working data used successfully in numerous installations for many years.

Field of Application of the Process Chart

The process chart lends itself equally well to the routine of production, selling, accounting and finance. It presents both simple and complicated problems easily and successfully; it provides records that are comparable; it assists in solving problems of notification and interdepartmental discrepancies, and it makes possible the more efficient utilization of similarities in different kinds of work and in the transfer of skill.

During the stress of unexpected rush in production, it is often considered advisable to continue existing practice in present processes, even though inefficient. On the other hand, when production is normal or slow, it is more generally conceded that processes can profitably be bettered.

The use of this process-chart procedure permits recording the existing and proposed methods and changes without the slightest fear of disturbing or disrupting the actual work itself, and also regardless of whether business conditions are usual or unusual.

Those who are interested in improving their process of production should utilize times of industrial depression for that purpose. Many concerns are now taking such action; many more could undoubtedly enter upon such procedure of scrutinizing all their processes with the idea of putting them in the best possible condition, if they knew a simple procedure of such analysis.

Simplicity of the Process Chart

The aim of the process chart is to present information regarding existing and proposed processes in such simple form that such information can become available to and usable by the greatest possible number of people in an organization before any changes whatever are actually made, so that the special knowledge and suggestions of those in positions of minor importance can be fully utilized.

The time has passed—if it ever existed—when the engineer prided himself upon the abstruse material that he studied and presented. Today engineering ranks with the other sciences in conveying ideas in a form that is immediately usable. We avoid "translating," interpreting and adapting, thus eliminating waste.

The process chart has met the tests of a satisfactory teaching device from the psychological standpoint, as well as of a satisactory working device from the engineering standpoint. It shows the planned process as well as the present process, and therefore gains the coöperation of those affected. In many instances recording industrial processes in process-chart form has resulted in astonishing improvements.

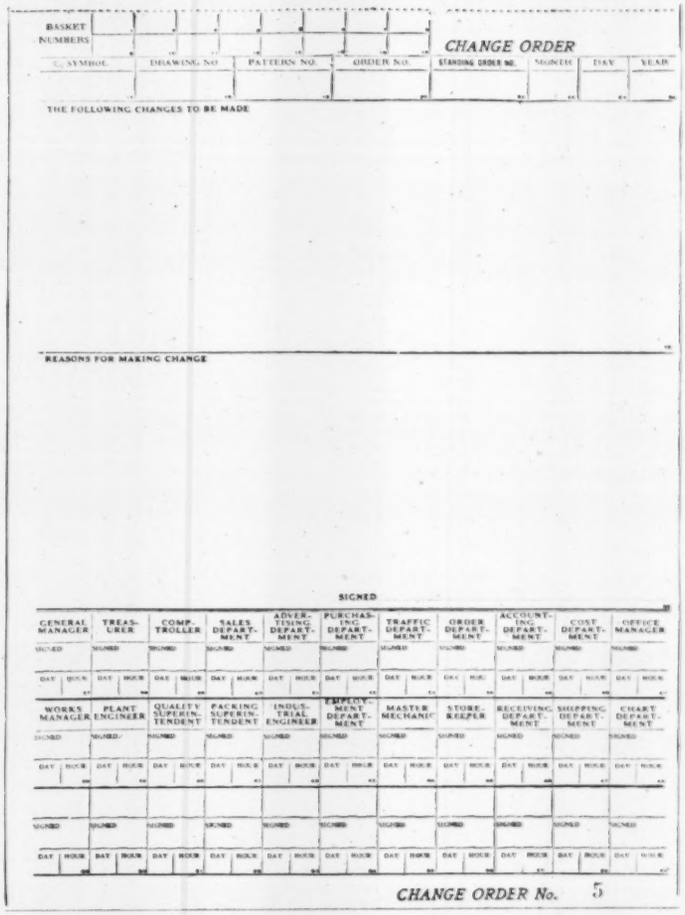

FIG. 1 STANDARD CHANGE-ORDER BLANK

Note that all blank forms should be thus numbered in each blank space to be filled out for describing clearly the One Best Way to Learn Work

Collecting the Information

Process-chart notes and information should be collected and set down in sketch form by a highly intelligent man, preferably with an engineering training and experience, but who need not necessarily have been previously familiar with the actual details of the processes. In fact, the unbiased eye of an intelligent and experienced process-chart maker usually brings better results than does the study of a less keen man with more special information regarding present practices of the processes. The mere act of investigating sufficiently to make the notes in good enough condition for the draftsman to copy invariably results in many ideas and suggestions for improvement, and all of these suggestions, good and bad, should be retained and filed together with the description of the process chart. These suggestions and proposed

[1] President, Frank B. Gilbreth, Inc., Mem.Am.Soc.M.E.

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improvements must be later explained to others, such as boards of directors, managers and foremen, and for best results also to certain workmen and clerks who have special craft or process knowledge. To overcome the obstacles due to habit, worship of tradition and prejudice, the more intelligence shown by the process-chart recorder, the sooner hearty coöperation of all concerned will be secured. Any one can make this form of process chart with no previous experience in making such charts, but the more experience one has in making them, the more certain standard combinations of operations, inspection and transporting can be transferred bodily to advantage to the charts of proposed processes.

Utilizing Suggestions

A new viewpoint concerning old conditions invariably comes to those members of the organization who have become so accustomed to the traditional method that they cannot easily visualize a new method without prejudice until they actually see it in a new graphical form. After the rough notes of the process-chart maker have been redrawn and blueprinted, they are later exhibited in the executives' theater.

If discussions arise as to the correctness of the presentation of the existing facts, or as to further details of the operations being studied, as shown by the simple symbols of the process chart, the room can be darkened and inexpensive glass diapositives projected on the wall. In addition, those present may be supplied with a special pocket folding stereoscope for use with the same glass diapositives.

As soon as the old or existing process is understood, a process chart of a better sequence and kind of operations which compose it is made. The procedure for this is the same for all cases as far as they are carried for the time being, but of course those processes which warrant the most study should be carried farthest in the process-chart procedure. The more people who see the process chart and the greater detail into which the regular process charts are divided, the more suggestions for improvement will come in.

Relation to Standardization

There is no process that warrants a process chart that does not warrant a "write-up" or "written system." The more care taken in making the written system, the more will develop the need for and appreciation of the value of clearly defined written standards. The better and the more detail in which the written system is developed, the better and easier will the standards and standing orders be developed.

Standards in writing should be made, even if there is not the managerial mechanism necessary to enforce and maintain them. Standards made even with enforcing mechanism absent will hasten the day when the enforcing and maintaining mechanism will be installed and continuously operated. The procedure of making the standards will invariably lead to the simplifying and improving of the various steps as shown on the process chart.

If it is desirable to study, improve and still further identify the subject-matter of each part of the process chart, it should be submitted to the regular routine process of standardization. A standard is a matter of degree. In its best form it is identified and defined with all the care and precision of the best practice for making the standing orders. The range, however, is dependent upon the degree of perfection with which provision has been made for enforcing and maintaining standards.

While on the subject of range, it is well to call attention to the remarkable attempts of Germany and Holland to provide national standards. These standards already cover a very wide field, from the style of the hand lettering and the rulings to be used on the paper on which the standards themselves are printed, to a metal seat for a harvester, tractor or tank. The range, in fact, already covers a surprisingly wide list of things which have not been properly standardized in America, and is intended eventually to cover everything that is manufactured in quantity, or that will for any other reason reduce costs or improve quality. Although there is much to criticise in these foreign standards, they are highly meritorious, worthy of continuous and careful attention, and a great credit to those who have devised them.

It must be remembered that the kind of standard adopted will affect the process almost invariably. Therefore standardization must be considered if the *one best way to do work* is to be derived.

Particular attention should be called to the fact that the creation of national standards of manufacture, even to the smallest components of the arts and trades, means also the stabilization of employment and business in general, because manufacturers without sufficient orders in their regular lines of business to keep going will find it more profitable, in many instances, to manufacture the

STORES REQUISITIONED
STORES BOUGHT
STORES RECEIVED
SEVERAL KINDS OF COMPONENTS - NOT DESIRABLE TO LIST INDIVIDUALLY
WORKED MATERIALS REQUISITIONED
WORKED MATERIALS ORDERED
WORKED MATERIALS ON HAND
MERCHANDISE IN STORAGE READY TO SHIP
STORAGE AS PART OF PROCESS
PERMANENT FILE OF ANY DOCUMENTS OR MATERIALS
TEMPORARY FILE OF ANY DOCUMENTS OR PAPERS
OPERATION SYMBOL - WITH NUMBER, SIGNIFIES OPERATION NO. 38 OR BY OPERATOR NO. 38
MOVED BY OPERATOR PERFORMING OPERATION NO. 38
MOVED BY MAN
MOVED BY BOY
MOVED BY MESSENGER BOY
MOVED BY ELEVATOR
MOVED BY PNEUMATIC TUBE
MOVED BY CONVEYOR
GRAVITY - MOVED BY GRAVITY CONVEYOR
BELT - MOVED BY BELT CONVEYOR
MOVED BY TRUCK:
ELECTRIC - (MOVED BY ELECTRIC TRUCK (OR SUBSTITUTE - GASOLINE, HAND), (LIFT, AS CASE MAY BE)
INFORMATION OR MESSAGE MOVED BY TELEPHONE
MOVED BY MAIL
INSPECTION FOR QUALITY
INSPECTION FOR QUALITY BY SEEING
INSPECTION FOR QUALITY BY SMELLING
INSPECTION FOR QUALITY BY HEARING
INSPECTION FOR QUALITY BY TASTING
INSPECTION FOR QUALITY BY FEELING
INSPECTION FOR QUALITY BY KINAESTHESIA
INSPECTION FOR QUANTITY
INSPECTION FOR QUANTITY BY { WEIGHING, WEIGHT COUNTING,
INSPECTION FOR QUANTITY BY COUNTING
INSPECTION FOR QUANTITY BY DRY OR LIQUID MEASURING
INSPECTION FOR QUANTITY BY SEEING { IS THERE AT LEAST ENOUGH? IS A PIECE MISSING FROM TRUCK OR PACKET?
INSPECTION FOR QUANTITY BY AUTOMATIC COUNTING
INSPECTION FOR QUANTITY AND QUALITY (QUANTITY MOST IMPORTANT).
INSPECTION FOR QUALITY AND QUANTITY (QUALITY MOST IMPORTANT)
OVER-INSPECTION FOR QUANTITY
OVER-INSPECTION FOR QUALITY
INSPECTION FOR QUANTITY ON EXCEPTION PRINCIPLE
INSPECTION FOR QUALITY ON EXCEPTION PRINCIPLE
OVER-INSPECTION FOR QUANTITY ON EXCEPTION PRINCIPLE
OVER-INSPECTION FOR QUALITY ON EXCEPTION PRINCIPLE
INSPECTION FOR QUANTITY AND OPERATION PERFORMED SIMULTANEOUSLY
INSPECTION FOR QUALITY AND OPERATION PERFORMED SIMULTANEOUSLY
INSPECTION FOR QUANTITY AND QUALITY AND OPERATION PERFORMED SIMULTANEOUSLY (QUANTITY MOST IMPORTANT).
INSPECTION FOR QUALITY AND QUANTITY AND OPERATION PERFORMED SIMULTANEOUSLY (QUALITY MOST IMPORTANT).
NO 2 485
BLANK FORM USED — INDICATES NO 2 COPY OF FORM 485; IF THERE IS BUT ONE COPY OF FORM MADE, FORM NUMBER APPEARS IN CENTER OF BLOCK.
DAILY EXCHANGE REPORT
REPORTS NOT HAVING FORM NUMBERS WILL HAVE BRIEF TITLE WRITTEN IN BLOCK
A SINGLE DEPARTMENT USED MORE THAN ONCE
BROKEN LINES INDICATE PROCESS OUTSIDE OF THIS DEPARTMENT CHARTED - USED ON DEPARTMENTAL CHARTS.
PROCESS WITHIN THE DEPARTMENT IS CONNECTED WITH CLOSED LINE.

FIG. 2 STANDARD SYMBOLS FOR PROCESS CHARTS

national standards and thus to turn their stores inventories into money immediately, rather than let their specially trained and skilled men leave them, with all the disadvantages of a high labor turnover. Here is an endless spiral of benefit, for the more chances there are for a manufacturer to dispose of his inventory for cash and keep his organization together a little longer, even in times of general timidity, the more he will dare be a purchaser of raw material, for the process for such emergencies can be standardized and ready. The result is standardization, with stabilization of employment, a quick capital turnover and a low labor turnover.

Many fear standardization of the component elements of a process chart as something from which, once done, it will be difficult to escape. For the purpose of allaying such groundless fears, the standard change order, Fig. 1, has been provided. This, when signed by the authorized party, instantly changes, or for a certain instance, or a certain time, waives the existing standard whether it relates to a thing, a method, a procedure or a process. It will be noted that this change-order blank contains provisions for the notification of, and acknowledgment of receipt of notification of, all persons who are concerned with, or interested in, the change.

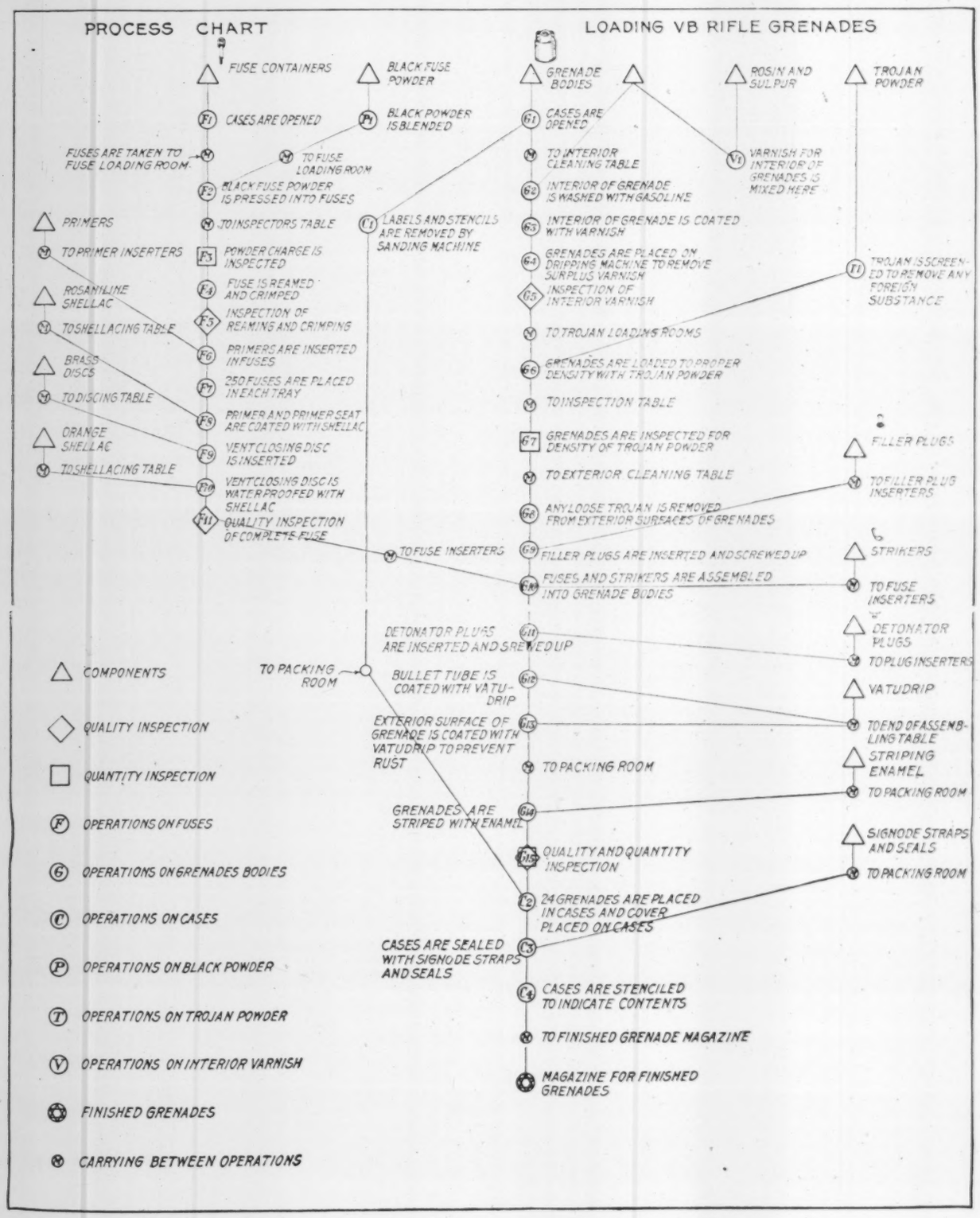
PROCESS CHART
LOADING VB RIFLE GRENADES
FUSE CONTAINERS
BLACK FUSE POWDER
GRENADE BODIES
ROSIN AND SULPUR
TROJAN POWDER
F1 CASES ARE OPENED
P1 BLACK POWDER IS BLENDED
G1 CASES ARE OPENED
FUSES ARE TAKEN TO FUSE LOADING ROOM
TO FUSE LOADING ROOM
TO INTERIOR CLEANING TABLE
V1 VARNISH FOR INTERIOR OF GRENADES IS MIXED HERE
F2 BLACK FUSE POWDER IS PRESSED INTO FUSES
G2 INTERIOR OF GRENADE IS WASHED WITH GASOLINE
PRIMERS
TO INSPECTORS TABLE
T1 LABELS AND STENCILS ARE REMOVED BY SANDING MACHINE
G3 INTERIOR OF GRENADE IS COATED WITH VARNISH
TO PRIMER INSERTERS
F3 POWDER CHARGE IS INSPECTED
G4 GRENADES ARE PLACED ON DRIPPING MACHINE TO REMOVE SURPLUS VARNISH
T1 TROJAN IS SCREENED TO REMOVE ANY FOREIGN SUBSTANCE
ROSANILINE SHELLAC
F4 FUSE IS REAMED AND CRIMPED
G5 INSPECTION OF INTERIOR VARNISH
TO SHELLACING TABLE
F5 INSPECTION OF REAMING AND CRIMPING
TO TROJAN LOADING ROOMS
F6 PRIMERS ARE INSERTED IN FUSES
G6 GRENADES ARE LOADED TO PROPER DENSITY WITH TROJAN POWDER
BRASS DISCS
F7 250 FUSES ARE PLACED IN EACH TRAY
TO INSPECTION TABLE
TO DISCING TABLE
F8 PRIMER AND PRIMER SEAT ARE COATED WITH SHELLAC
G7 GRENADES ARE INSPECTED FOR DENSITY OF TROJAN POWDER
FILLER PLUGS
ORANGE SHELLAC
F9 VENT CLOSING DISC IS INSERTED
TO EXTERIOR CLEANING TABLE
TO FILLER PLUG INSERTERS
TO SHELLACING TABLE
F10 VENT CLOSING DISC IS WATER PROOFED WITH SHELLAC
G8 ANY LOOSE TROJAN IS REMOVED FROM EXTERIOR SURFACES OF GRENADES
F11 QUALITY INSPECTION OF COMPLETE FUSE
TO FUSE INSERTERS
G9 FILLER PLUGS ARE INSERTED AND SCREWED UP
STRIKERS
G10 FUSES AND STRIKERS ARE ASSEMBLED INTO GRENADE BODIES
TO FUSE INSERTERS
DETONATOR PLUGS ARE INSERTED AND SCREWED UP
G11
DETONATOR PLUGS
TO PLUG INSERTERS
COMPONENTS
TO PACKING ROOM
BULLET TUBE IS COATED WITH VATUDRIP
G12
VATUDRIP
QUALITY INSPECTION
EXTERIOR SURFACE OF GRENADE IS COATED WITH VATUDRIP TO PREVENT RUST
G13
TO END OF ASSEMBLING TABLE
QUANTITY INSPECTION
TO PACKING ROOM
STRIPING ENAMEL
OPERATIONS ON FUSES
GRENADES ARE STRIPED WITH ENAMEL
G14
TO PACKING ROOM
OPERATIONS ON GRENADES BODIES
G15 QUALITY AND QUANTITY INSPECTION
SIGNODE STRAPS AND SEALS
OPERATIONS ON CASES
C2 24 GRENADES ARE PLACED IN CASES AND COVER PLACED ON CASES
TO PACKING ROOM
OPERATIONS ON BLACK POWDER
CASES ARE SEALED WITH SIGNODE STRAPS AND SEALS
C3
OPERATIONS ON TROJAN POWDER
C4 CASES ARE STENCILED TO INDICATE CONTENTS
OPERATIONS ON INTERIOR VARNISH
TO FINISHED GRENADE MAGAZINE
FINISHED GRENADES
MAGAZINE FOR FINISHED GRENADES
CARRYING BETWEEN OPERATIONS

FIG. 3 PROCESS CHART FOR LOADING RIFLE GRENADES

Note that in the lower right-hand corners of the various spaces in Fig. 1 there are small consecutive numbers. This is standardized to agree with write-ups and standing orders for using standard blank forms. It not only makes the writing of the standing order more simple, exact and clear, but it also shortens the time of the learning period for using these blank forms. This is a valuable feature at all times, but particularly useful during the transitory period of installing new methods of management.

Experience shows that if process charts are made use of, exceedingly few of the existing blank forms survive in their present form. The savings that can be made in any large organization resulting from submitting them to the test of this process will invariably prove it to be a good investment.

If all departments of the United States Government would adopt two features, namely:

a Put small numbers in each space to be filled out on all of its blank forms, and

b Make write-ups and standing orders of exactly how each blank form is to be filled out

and would then make a survey and criticism in accordance with the known laws of micromotion study, the resulting savings would be astounding.

We believe that, as a result, not one per cent of present blank forms would remain unchanged. All Government blank forms that we have seen violate all laws of motion study and learning methods of least waste.

The standing order is for enforcing standards and other standing orders. This has already been described in a paper before this Society.

The more detail in which the standing order is made, the better. The more the procedure is described by it, the greater will be the improvements and the greater the automaticity resulting.[1]

If any operation of the process shown in the process chart is one that will sufficiently affect similar work, then motion study should be made of each part of the process, and the degree to which the motion study should be carried depends upon the opportunities existing therein for savings.

If the operations are highly repetitive or consist of parts or subdivisions that can be transferred to the study of many other operations, then micromotion studies already made can be referred to; also new and further micromotion studies may be warranted in order that the details of method with the exact times of each of the individual subdivisions of the cycle of motions, or "therbligs," as they are called, that compose the one best way known, may be recorded for constant and cumulative improvement. Such motion study can be best visualized if seen in chart form, and similar process charts can be made of any or all of the large or small circles, squares and diamonds shown on the process charts. These subdivided motion charts can be made of each and all of the cycles in any given operation. Much benefit can often be derived, even if such motion charts are made roughly. For best results, and especially when complete records are required, such, for example, as when the process charts are of work that is highly repetitive, micromotion charts can be made which will give the maximum amount of analysis and visualization of component parts of the existing and proposed processes. These can be still further visualized by the chronocyclograph process. Both the chronocyclograph and the micromotion process have been described before the Society, and more recent development in these methods and devices for visualizing existing and proposed processes will be the subject of a later paper.

The records of the micromotion study and the chronocyclograph methods and devices present permanently all the facts in such form that they can be used at any time. These photographic records can be studied as slowly as desired, regardless of how fast the motions of the process were actually made, and the marvels of the details of superskill, unknown and unrecognized even by those who possess it, can be studied at will, leisurely and intensively, by learners everywhere, far as well as near. If desired, these errorless records may be used only as far as to fill the need of present requirements, or they may be laid away until further needs demand further study, such records being in such perfect detail that they are practically as usable when old as when new. These permanent records of complete sequences of details of complete processes furnish the foundation of the best kind of trade and industrial education, namely, the dissemination of detailed instructions as to the synthesized processes of the best workers obtainable.

These synthesized records of details of processes in turn may be further combined and large units of standard practice become available for the synthesis of complete operations in process charts.

While the process-chart methods will be helpful in any kind of work and under all forms of management, the best results can come only where there is a mechanism of management that will enforce and make repetitive the conditions of the standards.

Mechanism of Making Process Charts

There are shown herewith:

a The symbols used with their meanings (Fig. 2)

b Completed process chart (Fig. 3)

c Accompanying forms (Fig. 4)

d Illustrations of collecting and using data.

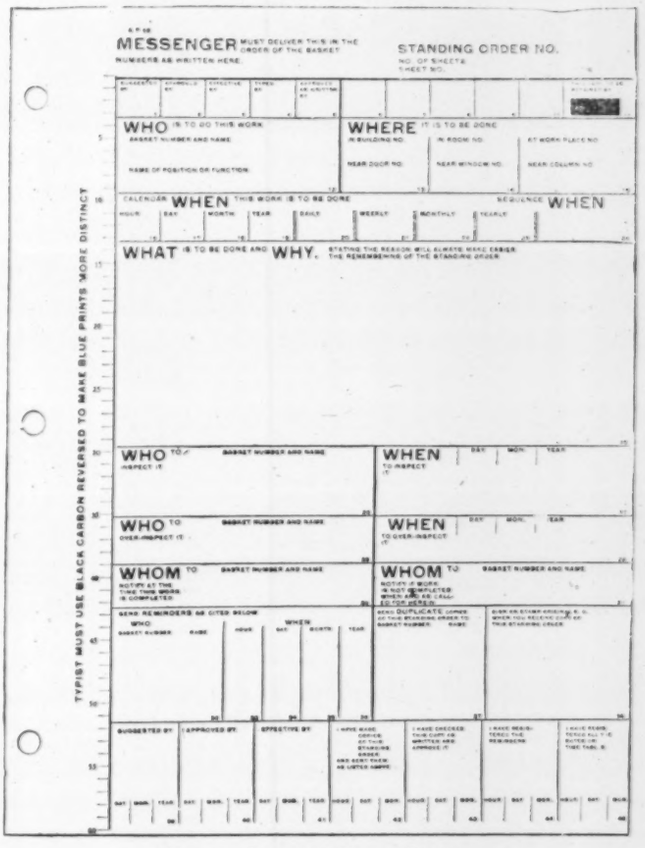

FIG. 4 STANDING-ORDER BLANK

Summary

The procedure for making, examining and improving a process is, therefore, preferably as follows:

a Examine process and record with rough notes and stereoscopic diapositives the existing process in detail

b Have draftsman copy rough notes in form for blueprinting, photographic projection and exhibition to executives and others

c Show the diapositives with stereoscope and lantern slides of process charts in executives' theater to executives and workers

d Improve present methods by the use of —

1 Suggestion system

2 Written description of new methods or "write-ups," "manuals," "codes," "written systems," as they are variously called

3 Standards

4 Standing orders

(*Continued on page 70*)

[1] See Psychology of Management; Applied Motion Study; and *Bulletin of the Taylor Society* for June 1921.

DISCUSSION OF ENGINEERING EDUCATION

(*Continued from page 7*)

problems of the world had been accomplished without laboratories.

E. H. Sniffin[3] had always held the opinion that it might be a good thing if professors were to enter business life and later return to the schools. Probably ninety per cent of those graduated from engineering schools would be judged ten years later upon the basis of their qualities rather than their engineering knowledge.

Joseph W. Roe[4] said that it was utterly impossible for those who were trying to teach the specialist in an undergraduate course in any way to meet the full demands. The best that they could do was to send out men wellgrounded in the fundamentals, and in his opinion, more important than that, with a right attitude toward work and toward investigation.

H. B. Shaw[5] could see no reason why some engineering schools should not develop along the line of requiring the arts degree for entrance, and others develop graduate courses in engineering. There was really no need to have all of the engineering schools teaching engineering in exactly the same way.

K. G. Matheson[6] felt that the so-called collateral studies should more largely predominate as being essential to the highest type of the engineer; but unless something like adequate compensation could be offered so as to attract the very highest type of intellectual ability and training, that the standards of engineering colleges would certainly become more mediocre.

D. C. Jackson[7] wished to emphasize the fact that while Mr. Otterson suggested in his paper that the test in the engineering school seemed to be of a character that solely selected the encyclopedic mind, the truth was that the tests are, as a rule, intended to select men from the standpoint of the powers of analysis and synthesis. These powers were in fact those which led to a final balanced judgment and the accomplishment of the object was one that could not be left solely to the engineering school to bring about the best results. It was necessary to have the advice of the industrialists to arrive at the highest type of professional engineers. Professor Jackson's own definition of it, some years back, was that the highest type of professional engineer is one that can conceive exact ideas in important engineering works or in engineering affairs.

J. P. Jackson[8] defined an engineer as a man who should be in charge of all phases of industry except financial investigation. Most of the men who had discussed the subject spoke of the importance of character and he felt that stressing this before an engineering faculty every few days would do a great deal of good.

C. A. Adams[9] said that he had not heard anything so encouraging from the standpoint of teachers of engineering for many years as the two papers presented by the industrialists. It showed a great advance in the attitude of industry toward engineering education, and the emphasis of the two papers, could be summed up in a very few words, namely, more emphasis on fundamentals, the ability to think rather than a superficial knowledge of the practical side of the subject, the amount of cramming necessary. Our engineering education was for the most part brutally superficial. The men did not get the fundamentals. He would guarantee to take 100 picked graduates of electrical engineering schools of this country and show that 90 per cent of them had no grasp whatever of the fundamentals of maximum and minimum; that is, a sound grasp, a visualizing of phenomena and seeing through the mathematical equation into the physics beyond, so understanding the physics that they could express it directly in mathematical form. That was the difficulty with our engineering education. What was wanted in every engineer and every student was the habit of honest thought, the habit of demanding a sound foundation for his analysis in whatever field he is, and of building soundly on that foundation, and not the habit of thinking he knows something and throwing from his memory the things which he ought to know.

L. W. Wallace[10] said that the world, in general, had come to learn that the engineering type of mind, the engineering type of approach, was the correct type of mind and type of approach to apply to many of the perplexing problems that were confronting society and the world today. It should be instilled into young engineers that they were in not only a learned profession, but in one of great potential possibilities, and that it was not only their duty to do their technical work well but to make their ability and training and analytical minds felt in dealing with the social problems of the day.

W. H. Carrier[11] agreed with Professor Adams in his statement that ninety out of one hundred students did not understand the fundamentals of engineering. In many cases he had personally found it necessary to learn a great many of these fundamentals after he had left college. He was not a particularly backward student, but there were too many things to do, and not enough time in which to emphasize the fundamentals. The tendency of all education had been to place too much emphasis on quantity rather than quality. Students had not been taught to reason. They had been pushed along too fast.

R. L. Sackett[12] said that one thing characteristic of the curriculum of Pennsylvania State College that could not be blamed on the industries, was a lack of elasticity. All students who entered, say, the electrical course was not made in the same mold. They might be of equal mental capacity, they might have good minds, but it was quite impossible at the present time, in the present state of the art that vocationally they should be the same to any extent at the beginning of their college course.

Frank B. Gilbreth[13] said that in training the individual for accomplishment, judgment should not be developed until after all facilities for measurements had been exhausted. He was not prepared, however, to criticise the product of professors who had done such wonderful work for such inadequate rates of compensation. Something would have to be done whereby the graduates from the colleges, when they came to the industries, would be prepared to do something to teach the worker.

Sidney Ash[14] wished to emphasize a point that Mr. Pratt had brought out in his paper, namely, that there had been a considerable improvement in several all-around capacity of the average technical student turned out in recent years. He came in contact with a great many men taken in by his company as college graduates, and thought that this improvement was about 30 per cent in the types that were coming through today.

[3] Mgr. Power Dept., Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

[4] Professor Industrial Engineering, New York University, New York, N. Y. Mem.Am.Soc.M.E.

[5] Henry L. Doherty & Co., New York, N. Y.

[6] Georgia Inst. of Technology, Atlanta, Ga.

[7] Professor Electrical Engineering, Massachusetts Institute of Technology. Mem.Am.Soc.M.E.

[8] Assistant to Chairman, Industrial Relations Committee, Philadelphia Chamber of Commerce, Philadelphia, Pa. Mem.Am.Soc.M.E.

[9] Professor, Harvard Engineering School, Cambridge, Mass. Mem. Am.Soc.M.E.

PREVENTION OF WASTES IN INDUSTRY

(*Continued from page 10*)

trol of the movement of material through the works from one operation to another and from one department to another; inadequate, or entire absence of provision for teaching or training operators, and minor executives; absence of effective means of recording attainments of workers, foremen, etc., so that their standing does not so much depend on actual performance as upon other things, some of them little if at all related to the work, such as nationality, religion, membership in secret organizations or fraternities, and sometimes plain graft.

When we set out to discuss an acknowledged fault our picture is necessarily rather a dark one. There is, of course, a bright side. We must work to make that bright side still brighter.

The greatest and most effective incentive for the prevention of industrial wastes is disarmament, so to speak; the cultivation of friendly relations between all those concerned in industrial enterprises; and the maintenance of such a system as will enable every man, from the highest to the lowest, to know what he is responsible for, to whom he is responsible, and that he personally will be credited and rewarded in proportion to service rendered.

[10] Executive Secretary, American Engineering Council, F.A.E.S., Washington, D. C. Mem.Am.Soc.M.E.

[11] Carrier Engineering Corporation, Newark, N. J. Mem.Am.Soc.M.E.

[12] Dean of Engineering, Pennsylvania State College, State College, Pa. Mem.Am.Soc.M.E.

[13] President, Frank B. Gilbreth, Inc., Montclair, N. J. Mem.Am.Soc. M.E.

[14] Educational Dept., General Electric Co., Pittsfield, Mass.

Radio Ship Control

Details of the Mechanical Changes Made in the U. S. S. "Iowa," by Means of Which the Vessel Was Operated and Maneuvered From a Distant Control Ship

By REAR-ADMIRAL R. S. GRIFFIN,[1] U. S. N., RETIRED

THE bombing tests which were carried out last summer against the old battleship *Iowa* (now designated Coast Battleship No. 4), during which that ship was operated and maneuvered under her own power without the presence on board of any of her officers or crew, created so much public interest that it has been suggested that a description of the mechanical changes that were made in her power equipment would be of interest to the members of The American Society of Mechanical Engineers.

REAR-ADMIRAL R. S. GRIFFIN

The *Iowa* is a ship 360 ft. long on the water line, of 72.2 ft. beam, and at a draft of water of 24 ft. has a displacement of 11,346 tons. She has twin-screw vertical triple-expansion engines of 11,800 indicated horsepower which are capable of giving her a speed of 17-knots. They are, of course, condensing.

The problem presented was so to modify her power plant that the ship would be susceptible of control by radio energy from another ship, both as to speed and direction, without any person being on board; that under this condition she should be capable of steaming for at least two hours at a speed of about 10 knots; and that means should be provided for automatically stopping the engines and shutting off the oil supply to the boilers after fifteen minutes of operation following a failure of the radio control.

The first part of the problem obviously pointed to an oil equipment as the only one that could be considered, and as the *Iowa* was a coal-burning ship it became necessary to transform some of her boilers to oil-burning. The speed requirement of 10 knots necessitated the development of but a small fraction of full power, and therefore it was necessary to convert only one-half her boilers for steaming at a very moderate rate of combustion.

The boilers are of the Scotch or return fire-tube type, and therefore are not so well adapted to oil burning as are water-tube boilers. However, for the power that had to be developed, this presented no difficulty. The lining with firebrick of the combustion chambers and the front end of the furnaces, and the protection of the joint of furnace and combustion-chamber sheet were the only alterations that were necessary to the fire side of the boilers. Alterations to the furnace fronts were, of course, necessary to accommodate the oil burners. All these alterations are indicated in Fig. 1.

Fuel-oil pumps were installed and were equipped with stop valves in their steam lines such that these valves could be instantly closed by radio signal if it were desired to stop the engines, or automatically in case of low water in the boilers.

In order to maintain a uniform water level, it was necessary to install feedwater regulators, which controlled the speed of the feed pumps in the usual manner.

The storage of fuel necessary to provide the continuous steaming laid down in the problem was easily effected by utilizing a few of the double-bottom compartments.

The only alterations that were necessary to the engines were certain modifications of the throttles to permit of radio control. The type of engines made it necessary to design for the condition in which the engines would be just turning over before the crew abandoned the ship, the function of the radio control then being to open the throttle to the extent necessary to secure the desired speed—which had been determined by test—and also to stop the engines should it be necessary so to do. The control was so effective that no difficulty whatever was experienced in controlling the speed, slowing down being accomplished in twenty seconds and increase to full speed in three minutes.

Such auxiliaries as air pumps, circulating pumps and bilge pumps, the operation of which at normal speed would have no material influence on either the speed of the engines or the boiler conditions, were unaffected by the conditions of the problem and were untouched after once having been set at the proper speed of operation.

The points that have thus far been mentioned pertain solely to the propulsion of the ship. In order to maneuver her, which was one of the most important considerations in connection with the bombing tests, it was necessary that the steam steering engine be under as complete radio control as the main engines. Ordinarily this is accomplished through wire-rope transmission from the steering wheel on the bridge to the shaft which operates the engine-control valve. For this test a small motor was installed and connected by chain drive to the control-valve shaft. It was provided with an automatic reversing contactor controller which was operated through the radio-control panel or automatically through the gyro clutch. It proved to be an admirable substitute for the hand steering wheel.

Naturally, considerable electric energy would be necessary to operate the various radio circuits and apparatus, but as operation of the ship's electric plant during the test would unnecessarily complicate the problem without supplying any useful information respecting the results which it was desired to accomplish, it was decided to provide storage batteries and control panels for the several circuits.

In preparation for radio control the oil-fuel pumps, the air and circulating pumps, the feed pumps, an air compressor and a bilge pump are put in operation, and the steering engine warmed up and operated by hand control. When normal conditions are

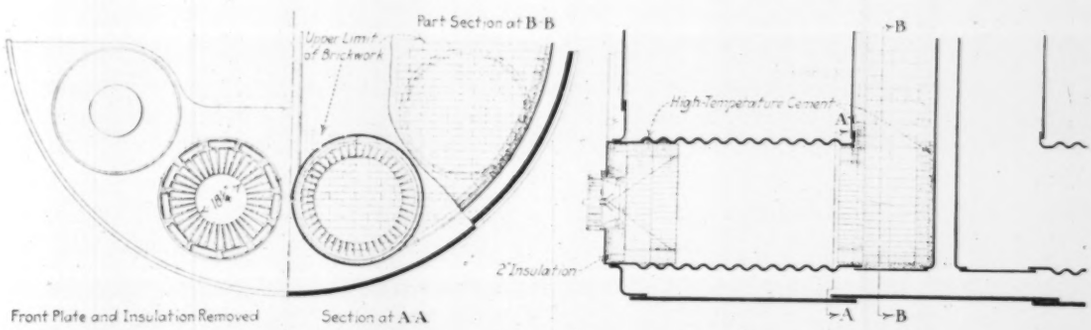

FIG. 1 ALTERATIONS IN SCOTCH MARINE BOILER TO ADAPT IT TO OIL BURNING

[1] Washington, D. C. Hon. Mem.Am.Soc.M.E.

established, the main engines are started and kept running at dead-slow speed, the bridge control of steering engine thrown out, all batteries connected to bus bars, and switches to radio-control instruments and gyro compass, and steering-engine motor thrown in. Everything is now in readiness for radio control and the signal given to "abandon ship." As soon as the boats that take off the

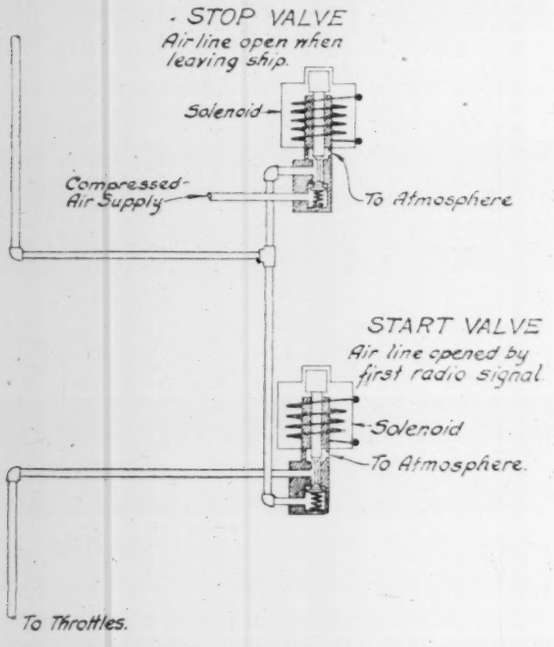

Fig. 2 Radio-Control Valves for Opening and Closing Throttle-Control Valve, Fig. 3

crew are clear of the ship, she is immediately put under radio control by the control ship, which in this case was the battleship

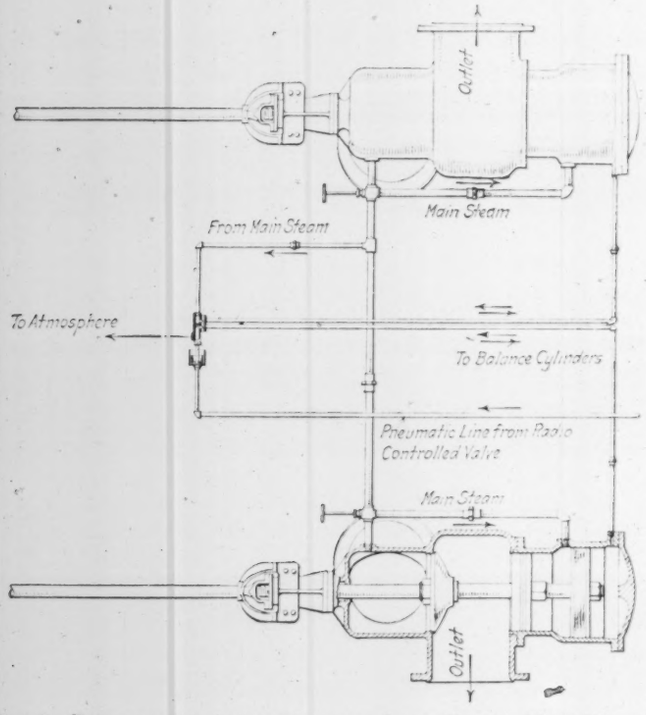

Fig. 3 Diagrammatic Arrangement of Quick-Closing Main Engine Throttle Valves and Control Valve

Ohio, which during the past two years has rendered excellent service in radio experimental work under the Bureau of Engineering of the Navy Department.

The method of control will be understood from the following:

When the air compressor is started, pressure is brought up to the "stop valve," Fig. 2, which may be called the master radio-control valve. This valve is then energized from the ship's control room, by which action air is admitted to the balance cylinder of a quick-closing valve in the steam line to the fuel-oil pump and up to the "start valve," as indicated in the sketch. The first signal from the control ship energizes the "start valve," Fig. 2, which admits air to the piston of the throttle-control valve shown in Fig. 3. This throws the piston to the left, shuts off steam from the upper balance pistons, and the throttles open to the extent necessary for the desired speed, the lower balance piston being smaller in diameter than the upper one.

The opening by the control ship of the radio circuit to "start valve" closes the valve to air pressure under the action of the spring, and the pressure in the line to throttle-control valve is

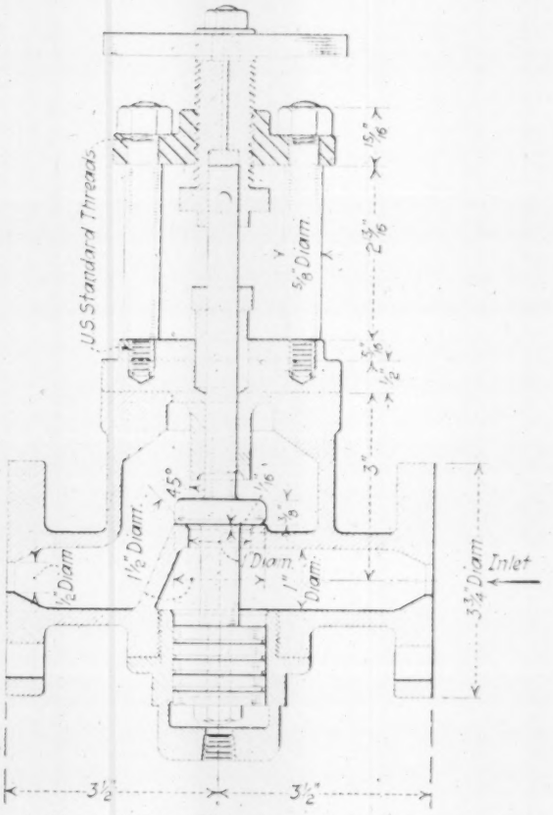

Fig. 4 Type of Valve Used in Controlling Fuel-Oil Pump

released. When this occurs, the piston valve is thrown far enough to the right to uncover the port to the steam pipes leading to the upper chambers of the balance cylinders and the throttles close under the action of the steam pressure.

Similar action takes place when it is desired to stop the fuel-oil pump. The proper opening of the steam valve to this pump having been previously determined and air pressure being on its balance piston, a radio signal releases the air pressure, whereupon the valve closes automatically under the influence of steam pressure on the other side of the balance piston. The throttles close at the same time. Fig. 4 shows the type of valve used.

The requirement that the engines and the fuel-oil pumps should stop automatically after a certain lapse of time in case radio control failed was accomplished by the introduction of a "time limit clock" in the "stop valve" circuit. After the lapse of time for which it had been set, the clock opened this circuit, and the steam valves to the oil pumps and the engine throttles closed in the manner previously described.

The low-water alarm was of the usual type except that, instead of blowing a whistle, the steam was used to operate a piston that opened the "stop valve" circuit.

The principal radio-control apparatus is covered by patents of John Hays Hammond, Jr., who permitted the free use of it for this test. It was constructed by the General Electric Company under the supervision of Mr. Hammond and the Bureau of Engi-

(Continued on page 70)

Code for Displacement Compressors and Blowers

Preliminary Draft of the Fifth in the Series of Nineteen Codes in Course of Preparation by the A.S.M.E. Committee on Power Test Codes

IN 1918 the Power Test Committee of the A.S.M.E. was reorganized to revise and enlarge the Power Test Codes of the Society, published in 1915. The Committee is a large one, consisting of a Main Committee of 25 under the chairmanship of Fred R. Low, and 19 Individual Committees of specialists who are drafting codes for the different classes of apparatus comprised in power-plant equipment. Below is reproduced the fifth of these codes to be completed, namely, the Test Code for Displacement Compressors and Blowers.

The Individual Committee which developed this Code is headed by Mr. Paul Diserens as Chairman, and consists of the following men: Hugh V. Conrad, John F. G. Miller, Snowden B. Redfield,[1] Carl G. Sprado, Charles Prentice Turner, and John T. Wilkin. This Committee will welcome suggestions for corrections or additions to this draft of its Code and especially desires constructive comment on Pars. 10 and 10a. These should be addressed to the Chairman, care of The American Society of Mechanical Engineers.

Introduction

1 The code for displacement compressors and blowers is intended as a guide for testing reciprocating piston compressors and blowers, as well as rotary compressors and blowers of the positive displacement type. The tables for data and results apply to complete units, including compressor element and driving element, but the code itself constitutes a set of rules for the test of the compressor element only. For the driving element the codes for steam engines, steam turbines, internal-combustion engines, water wheels, etc., depending upon the method of drive, should be consulted and followed.

Object

2 In accordance with the "General Instructions," the object of the test should be determined and recorded. If th object relates to the fulfilment of a contract guarantee, an agreement should be made between the interested parties concerning all matters about which dispute may arise, as noted in Par. 2 of the "General Instructions," and the points agreed upon should be stated in the report of the test.

Measurements

3 The measurements to be made in any test of a compressor or blower have for their purpose the determination of the following essential quantities:

(*a*) The quantity of air or gas compressed and delivered expressed in cubic feet in terms of gas or air under intake conditions of temperature and pressure
(*b*) The average intake and discharge pressures
(*c*) The power required to compress and deliver the measured amount of air or gas handled
(*d*) The amount of steam, electrical energy or fuel, depending upon the method of drive, consumed by the driving element during the test.

In order to arrive at these quantities and as a means of interpreting them, the following measurements are necessary:

(*e*) Diameter and stroke of compressor cylinders, or equivalent dimensions for positive rotary blower
(*f*) Diameter of piston rods
(*g*) Number and dimensions of intercoolers and aftercoolers
(*h*) Principal dimensions of driving element (See appropriate code)
(*i*) Speed in r.p.m. and total number of revolutions
(*j*) Indicated horsepower in compressor and driving cylinders (steam engine, internal-combustion engine, etc.)
(*k*) Discharge pressure
(*l*) Intake pressure
(*m*) Intercooler pressure
(*n*) Barometric pressure
(*o*) Temperature of air or gas before and after each stage
(*p*) Temperature of cooling water at inlet and outlet of each jacket and cooler
(*q*) Quantity of jacket and cooling water
(*r*) Temperatures, pressures, etc., steam, gas or oil as applied to driving element (See appropriate code).

Instruments and Apparatus

4. The instruments and apparatus necessary for the measurement of the quantities enumerated in Par. 3 are:

(*a*) Gaging tank and nozzle or orifice for measuring air or gas compressed
(*b*) Tanks and platform scales of suitable capacity for measuring the quantity of condensed steam when a steam engine constitutes the driving element or for measuring fuel oil when an oil engine constitutes the driving element
(*c*) Water meters or calibrated tanks, or tanks and platform scales for measuring jacket and intercooler circulating water
(*d*) Pressure gages, vacuum gages, water and mercury manometers, and thermometers
(*e*) Barometer
(*f*) Steam calorimeter (for steam-engine-driven compressor)
(*g*) Voltmeter, ammeter, wattmeter and power-factor meter for measuring electrical input for motor-driven compressors
(*h*) Revolution counter
(*i*) Indicators
(*j*) A planimeter
(*k*) A deadweight gage tester

Directions for the use and calibration of instruments and apparatus enumerated above are given in Pars. Nos. —— of the code on "Instruments and Apparatus."

4a The measurement of the quantity of air compressed shall be by the following method:

(*a*) In the case of a compressor or blower: Flow into the atmosphere through nozzle or orifice from a gaging tank on the discharge side of the compressor or blower
(*b*) In the case of a vacuum pump: Flow from atmosphere through a nozzle or orifice into a gaging tank on the intake side of the vacuum pump.

4b Where the foregoing prescribed method is impracticable, as for example in the case of a compressor handling inflammable gas or gas which cannot be wasted, one of the following instruments may be used. These alternatives are listed in order of preference.

(*c*) Venturi meter
(*d*) Nozzle or orifice in discharge line
(*e*) Receiver tanks of known capacity into which the discharge from the compressor may be delievered, to be used only for compressors working at a discharge pressure of 1000 lb. per sq. in. or greater.

If method (*c*) or (*d*) is used, the instrument should be applied in a pipe through which the gas is permitted to flow under a pressure considerably less than the compressor discharge pressure. The reduction in pressure can be brought about by throttling and will result in eliminating, or at least minimizing, the pulsations in flow induced by the compressor.

4c The kind and size of gaging tank and nozzle or orifice selected will depend upon the particular method chosen for measuring the quantity of air or gas compressed. Whenever possible a low-pressure nozzle or orifice shall be used. A low-pressure nozzle is one through which the drop in pressure is small, that is, one in which the upstream absolute pressure is less than twice the downstream absolute pressure. Its use for high- or moderate-pressure compressors involves throttling the gas before it is admitted into the gaging tank to such an extent that all, or nearly all, pulsation is eliminated. If a high-pressure nozzle is selected, that is, one through which the drop in pressure is relatively large ($P_1 > 2P_2$), care should be exercised to select an orifice of a size sufficient to insure as much throttling between the discharge receiver and the gaging tank as possible.

4d The measurement of the intake and discharge pressures shall be by gage attached at the desired point, the fluctuations of which are reduced as far as may be by choking the gage cock. When extreme accuracy is desired or when the fluctuations are large, the average pressure may be found by working up pipe diagrams taken at or near the same point, thereby determining the mean pressure for the entire stroke.

[1] Mr. Redfield approves the draft of the Code as here printed with the exception of Par. 10a. He believes that the amount of moisture removed in the separator should be weighed and that this weight should enter into the calculations.

Preparation

5 Before proceeding with a test of a compressor or blower, Pars. 4 to 8 of the "General Instructions" should be carefully read. The dimensions and physical conditions not only of the compressor but of all the associated parts of the plant essential to the object of the tests should be determined and carefully recorded.

5a *Dimensions.* The dimensions of the compressor cylinders should be determined by actually measuring the machine itself without reference to the drawings. If the cylinders are much worn the average diameter should be taken, but proper record of the fact should be noted.

5b The method for measuring clearance will depend upon the particular design of the compressor in question. In a reciprocating displacement compressor with valves of the automatic type, the most satisfactory method will be to calculate the clearance from the measured dimensions of the cylinder, its several ports, and passages. If detailed drawings are available it will be found convenient to check each dimension of the parts involved by actual measurement and from this information compute the clearance volume. If mechanically operated valves are used, or if the construction of the valves of the automatic type is such as to permit blocking them in their closed position, the clearance may be obtained by the water-measurement method. This should only be attempted, however, when extreme accuracy is necessary or desirable. To carry out this method, refer to Par. 5a of the Code for Steam Engines.

5c The area of the compressor cylinder-jacket surface is that part of the cylinder wall or cylinder-head wall in contact with the water circulation and should be measured on the dry side of the metal.

5d The intercooler and aftercooler surface should be measured on the dry side of the cooling surface. Surface in contact with the air to be cooled on the one side and atmospheric air on the other side should not be included as cooling surface. If a record of its amount is made it should be listed as a separate item.

Operating Conditions

6 As pointed out in the "General Instructions," Par. 19, in all tests in which the object is to determine the performance under conditions of maximum efficiency, or where it is desired to ascertain the effect of predetermined conditions of operation, all such conditions which have an appreciable effect upon the efficiency should be maintained as nearly uniform during the trial as the limitations of practical work will permit.

Tests to determine the performance under working conditions in which no attempt at uniformity is made are not advised, since the only available method of air measurement involves the determination of the rate of flow and total quantities of gas or air must be computed from the observed rate. Unless all conditions of operation are kept uniform or nearly uniform, the results obtained will not be of any value.

Starting and Stopping

7 The compressor should be operated under test conditions for a considerable period before a record of its performance is made. This period should be of a duration sufficient to bring about a steady condition of pressure, temperature and speed. In this connection Pars. 16 and 18 of the "General Instructions" should be carefully noted.

Duration

8 The duration of compressor tests will generally be governed by the requirements in so far as the driving element is concerned, and for direction as to the necessary period reference to the appropriate code governing the driving element should be made. In the case of a motor-driven unit accurate results can be obtained from very short tests, the controlling factor being the time required to record enough sets of observations to demonstrate the uniformity of running conditions during the test.

Record

9 The general data should be recorded as pointed out in Pars. 20 to 30 of the "General Instructions." Instruments should be read and indicator cards taken from each end of each cylinder at least quarter-hourly when the conditions are uniform, and oftener when there is much variation. For short tests referred to in Par. 8, readings and cards should be taken much more often. If there are wide fluctuations in readings they should be shown by recording instruments. Each indicator card should be marked with the number, date, time, scale of spring, and end of cylinder, and on one card of each set the readings of the pressure gages should be recorded. The log should contain the record of the readings of discharge, intercooler and intake gages, thermometers, revolution counter, speed indicator, gaging-tank pressures and temperatures, and all other instruments, and these readings should be obtained at practically the same time the indicator cards are taken. The areas, lengths, and mean effective pressures shown by the indicator cards should also be entered in the log. If complete test data are required, representative pipe diagrams should be taken with an indicator applied near the cylinder port and operated by connection to a reducing motion driven from the engine or compressor crosshead.

9a A set of specimen indicator diagrams should be carefully selected from the whole number taken, and these should be embodied in the record. The specimen cards selected should be such as to show the average conditions of pressure. If pipe or port diagrams are obtained, specimens of these should also be placed in the record.

Calculation of Results

10 *Volume of Air or Gas Compressed.* The measurement of the amount of air or gas through a nozzle, orifice, or venturi tube results in a determination expressed in pounds per unit of time. (See Code for Instruments and Apparatus, Par. —.) The results obtained must therefore be reduced to terms of volume at the temperature and pressure obtaining at the compressor or blower intake. For this purpose the required specific weight at intake conditions may be calculated from the following formula:

$$\text{Specific weight} = \frac{P \times 144}{RT} \text{ in lb. per cu. ft.}$$

where P = absolute intake pressure, lb. per sq. in.
T = absolute intake temperature, deg. fahr.
R = constant (= 53.3 for air).

This assumes that the fluid compressed is ideal gas, an assumption quite satisfactory for air. The weight of air or gas per minute as shown by nozzle measurement divided by the specific weight at intake conditions is equal to the volume of free gas or air compressed per minute.

When natural gas is compressed the value for R is not nearly enough constant under all conditions to satisfy engineering requirements and a correction must be made, depending in amount on the ratio of compression and the nature of the gas. (See Code for Instruments and Apparatus, Par. —.)

10a[1] *Correction for Moisture.* In the case of a compressor handling moist air, if some of the moisture is condensed during the process of intercooling and aftercooling, the air under discharge pressure will be saturated. In order to correct the rate of flow as shown by the orifice results it will only be necessary to figure the capacity of the compressor in terms of a total pressure equal to the sum of the partial pressure of air under intake conditions plus the partial pressure of the moisture in moist air having a relative humidity less than that observed in the intake by an amount representing the moisture removed in the cylinders, intercoolers, and aftercoolers. To determine this equivalent pressure to be used in calculating the specific volume, the following formula may be used:

$$P = P_d + P_m$$

where P_d = partial pressure for air in intake
P_m = partial pressure of moisture corrected for water of condensation removed from compressor and coolers.

To arrive at the value for P_m, proceed as follows: In the steam tables find the density of steam corresponding to the observed temperature in the discharge receiver. Multiply this first by the ratio of the observed absolute intake pressure to the observed absolute discharge pressure and then by the ratio of the absolute temperature in the discharge receiver to the absolute temperature

[1] See footnote on preceding page.

in the intake. The value thus obtained will be a hypothetical density, opposite which in the pressure column of the steam table will be found the desired partial pressure P_m.

It should be noted that the correction for moisture may be properly made only if moisture in the form of condensate is actually removed from the coolers. Care should be taken to make sure that the discharge temperature and pressure used is taken at or near the outlet of the cooler. If no aftercooler is installed the discharge temperature and pressure at or near the outlet of the intercooler should be used in the calculation outlined above.

11 *Indicated Horsepower.* The indicated horsepower for each end of the cylinder is found by using the formula:

$$\text{I.hp.} = \frac{PLAN}{33,000}$$

where P represents the mean effective pressure in pounds per square inch, L the length of the stroke in feet, A the area in square inches of the piston less the area of the piston rod, if any, and N the number of revolutions per minute. The total horsepower of the cylinder is the sum of the horsepower developed in the two ends.

11a *The Mean Effective Pressure* should be found by dividing the area of the indicator diagram in square inches as determined with a planimeter by the length of the diagram in inches, and multiplying the quotient by the average scale of the indicator spring. If a planimeter is not available, the approximate mean effective pressure may be determined by finding the average height of the diagram in inches as obtained by averaging a suitable number or ordinates, at least twenty, measured between the lines of the forward and return strokes, and then multiplying this average by the scale of the spring. The length of the indicator diagram is the measured distance along the atmospheric-pressure line between ordinates erected perpendicular to it and passing through the ends of the indicator diagram.

12 *The horsepower required to compress isothermally* the measured quantity of air at average speed of the compressor is found by multiplying the volume compressed per minute in cubic feet corrected to intake pressure and temperature by the absolute intake pressure in pounds per square foot and by the hyperbolic logarithm of the ratio of the absolute discharge pressure to the absolute intake pressure and dividing the product by 33,000.

13 *The Gross Horsepower* is the indicated horsepower in the steam or power cylinders in the case of a steam or internal-combustion-engine-driven compressor; the electrical horsepower multiplied by the motor efficiency in the case of a motor-driven compressor; and the brake horsepower delivered to the compressor shaft in the case of a belt-driven compressor. In the case of a compressor driven through belt, gear, etc., the power absorbed by the belt, gear, etc., must be taken into account.

14 *Electrical Horsepower.* The electrical horsepower of a motor is found by dividing the input at the terminals expressed in kilowatts by the constant 0.746. In the case of an alternating-current motor, the input determined, whether expressed in electrical horsepower or kilowatts, should be the total input. When the power for excitation or ventilation is taken directly from the compressor shaft, the total input is that indicated at the a.c. motor terminals; but if the motor efficiency as given does not account for the exciter input and exciter loss, the total electrical horsepower used in calculating the gross horsepower (Par. 13) is that indicated at the motor terminals less an equivalent current required to run the exciter.

15 *Volumetric Efficiency.* The volumetric efficiency is the ratio of the capacity of the compressor to displacement. The capacity is the actual amount of air or gas compressed and delivered, expressed in cubic feet per minute at intake temperature and pressure.

16 *Mechanical Efficiency.* The mechanical efficiency is the ratio of the air indicated horsepower to the indicated horsepower in the power cylinders in the case of a steam-driven or internal-combustion-engine-driven compressor, and to the brake horsepower delivered to the shaft in the case of a power-driven machine.

17 *Compression Efficiency.* The compression efficiency is the ratio of the work required to compress isothermally all the air or gas delivered by the compressor to the work done within the compressor cylinder, as shown by the indicator cards. The two factors involved in this ratio are defined in Pars. 12 and 11, respectively.

18 *Overall Efficiency.* The overall efficiency is the product of the compression efficiency and the mechanical efficiency.

The Data and Results

19 The data and results should be reported in accordance with the tables given herewith, adding lines for data not provided for or omitting those not required, as may conform to the purposes of the test. Unless otherwise indicated, the items should be the averages of all observations.

Table 1 constitutes the data and results applying to the compressing element and Tables 2, 3 and 4 the data and results applying to the driving element for motor, steam-engine and internal-combustion-engine drive, respectively. In reporting a test Table 1 should be combined with its appropriate driving-element table, the two being thrown together to form one complete table. The items of Tables 1, 2, 3 and 4 are so numbered as to indicate how this may be done most conveniently.

TABLE 1 DATA AND RESULTS OF TEST ON POWER-DRIVEN DISPLACEMENT AIR COMPRESSOR

COMPRESSING ELEMENT
(A.S.M.E. Code of 1923)

General Information

(1)	Date of test	
(2)	Location	
(3)	Owner	
(4)	Builder	
(5)	Test conducted by	
(6)	Object of test	

Description, Dimensions, Etc., of Compressor

(7)	Type of compressor (single or multiple stage, and kind of gas)	
(8)	Type of compressor valves	
(9)	Method of driving compressor	
(10)	Method of volume control	
(11)	Rated discharge pressure	lb. per sq. in.
(12)	Rated speed	r.p.m.
(13)	Rated displacement	cu. ft. per min.
(14)	Rated output expressed in volume (air or gas at intake pressure and temperature)	cu. ft. per min.
(15)	Type of intercoolers and aftercooler	

		1st intercooler	2nd intercooler	3rd intercooler
(16)	Area of water-cooled surface, sq. ft. See Par. 5			

		1st stage	2nd stage	3rd stage
(17)	Diameter of compressor cylinders, in.			
(18)	Stroke of pistons, ft.			
(19)	Diameter of piston rods or tail rods, in.			

		1st stage	2nd stage	3rd stage
(20)	Clearance in terms of piston displacement, per cent			
	(*a*) Clearance, head end			
	(*b*) Clearance, crank end			
	(*c*) Clearance, average			
(21)	Air cylinder ratio based on piston displacement:			
	(*a*) 1st stage to 2nd stage			
	(*b*) 2nd stage to 3rd stage			
	(*c*) Total (1st stage to final stage)			
(22)	Horsepower constant, air cylinder:	1st stage	2nd stage	3rd stage
	(*a*) Head end (stroke × net piston area ÷ 33,000)			
	(*b*) Crank end (stroke × net piston area ÷ 33,000)			
(23)	Area of compressor cylinder jacketed surface	1st stage sq. ft.	2nd stage sq. ft.	3rd stage sq. ft.
(24)	Length and cross-sectional area, intake pipe	ft.	ft.	ft.
(25)	Diameter of final discharge pipe	in.	in.	in.

Description, Dimensions, Etc., of Compressor Driving Element
(See Tables 2, 3 or 4)

Test Data and Results

(40)	Duration of test	hr
	Average Pressures	
(41)	Barometric pressure	in. of mercury
	(*a*) Corresponding absolute pressure	lb. per sq. in.
(42)	Pressure by gage at intake near cylinder	lb. per sq. in.
	(*a*) Corresponding absolute pressure	lb. per sq. in.

(b) Maximum pressure above or below atmosphere by intake-pipe diagram ..... lb. per sq. in.
(c) Minimum pressure above or below atmosphere by intake-pipe diagram near cylinders. (See Par. 4d) ..... lb. per sq. in.

(43) Pressure above atmosphere in discharge pipe near high-pressure cylinder by gage ..... lb. per sq. in.
(a) Corresponding absolute pressure ..... lb. per sq. in.
(b) Maximum pressure above atmosphere, discharge pipe diagram near high-pressure cylinder ..... lb. per sq. in.
(c) Minimum pressure above atmosphere, discharge pipe diagram near high-pressure cylinder. (See Par. 4d ..... lb. per sq. in.

(44) Pressure in 1st intercooler by gage ..... lb. per sq. in.
(See Par. 4d)

(45) Pressure in 2nd intercooler by gage ..... lb. per sq. in.
(See Par. 4d)

Average Temperatures

(50) Engine-room temperature ..... deg. fahr.
(51) Temperature of air or gas near intake, dry-bulb ..... deg. fahr.
(52) Temperature of air or gas near intake, wet-bulb ..... deg. fahr.

	1st cyl.	2d cyl.	3d cyl.
(53) Temperature of air or gas in suction port, deg. fahr.			
(54) Temperature of air or gas in discharge port, deg. fahr.			
(55) Temperature of jacket cooling-water inlet, deg. fahr			
(56) Temperature of jacket cooling-water outlet, deg. fahr			

	1st cooler	2d cooler	inter-cooler
(57) Temperature of cooler circulating water inlet, deg. fahr			
(58) Temperature of cooler circulating water outlet, deg. fahr			

(59) Temperature of air or gas in gaging tank at upstream side of orifice ..... deg. fahr.

Total Quantities

(65) Relative humidity of air or gas at intake of compressor (use Smithsonian Tables) ..... per cent.
(66) Air compressed and delivered to line ..... lb.
(See Pars. 4a and 4b)
(67) Air or gas compressed and delivered to line expressed in cu. ft. at intake pressure and temperature ..... cu. ft.
(See Pars. 10 and 10a)

	1st cyl.	2d cyl.	3d cyl.
(68) Cooling water supplied jackets, lb.			

	1st stage	2d stage	after cooler
(69) Cooling water supplied coolers, lb			

Unit Quantities

(76) Volume of air or gas at intake pressure and temperature compressed and delivered per minute [Item 67 ÷ (60 × Item 40)] ..... cu. ft.

	1st cyl.	2d cyl.	3d cyl.
(77) Cooling water supplied jackets, lb. or gal. per min. [Item 68 ÷ (60 × Item 40)]			

	1st stage	2d stage	after cooler
(78) Cooling water supplied intercoolers, lb. or gal. per min. [Item 69 ÷ (60 × Item 40)]			

Speed

(82) Total number of revolutions as shown by compressor counter .....
(83) Revolutions per minute [Item 82 ÷ (60 × Item 40)] ..... r.p.m.
(84) Average piston speed ..... ft. per min.

Power

(85) Indicated horsepower of compressor cylinders, whole compressor ..... i.hp.
(86) Low-pressure compressor cylinder, horsepower:
Crank end ..... i.hp.
Head end ..... i.hp.
(87) Intermediate-pressure compressor cylinder horsepower:
Crank end ..... i.hp.
Head end ..... i.hp.
(88) High-pressure compressor cylinder horsepower:
Crank end ..... i.hp.
Head end ..... i.hp.
(89) Friction horsepower [Item 101 (Table 2) or 90 (Table 3)—Item 85] ..... i.hp.

Power Input

(See Tables 2, 3 or 4)

Economy Results

(102) Gross horsepower per cu. ft. of air or gas delivered per min. at intake pressure and temperature (See Par. 13) ..... hp.
(103) Electrical horsepower per cu. ft. of air of gas delivered per min. at intake pressure and temperature (See Par. 14) ..... hp.
(104) Indicated horsepower in compressor cylinder per cu. ft. of air or gas delivered per min. at intake pressure and temperature (Item 85 ÷ Item 76) ..... hp.

Efficiency Results

(109) Horsepower required to compress isothermally measured quantity of air or gas at average speed of compressor during test (See Par. 12) ..... hp.
(110) Volumetric efficiency (See Par. 15) ..... per cent
(111) Compression efficiency (See Par. 17) ..... per cent
(112) Mechanical efficiency (See Par. 16) ..... per cent
(113) Overall efficiency (See Par. 18) ..... per cent

TABLE 2 ADDITIONAL ITEMS APPLYING ONLY WHEN THE DRIVING ELEMENT IS AN ELECTRIC MOTOR

Description, Dimensions, etc., of Compressor Drive

(26) Type of motor .....
(27) Rated power of motor .....
(28) Volts .....
(29) Amperes .....
(30) Phase .....
(31) Cycles .....
(32) Revolutions per minute .....
(33) Type and rating of exciter .....
(a) Volts .....
(b) Amperes .....

Power Input

(90) Volts .....
(91) Amperes per phase .....
(92) Power factor (from meter) .....
(93) Exciter:
(a) Volts .....
(b) Amperes .....
(94) Efficiency of exciter (from builder's test) ..... per cent
(95) Horsepower input to motor (calculated from voltmeter, ammeter and power-factor meter) ..... hp.
(96) Horsepower input to motor by wattmeter ..... hp.
(97) Efficiency of motor (from builder's test) ..... hp.
(98) Net motor horsepower ..... hp.
(99) Horsepower output for exciter ..... hp.
(100) Net horsepower to drive exciter ..... hp
(101) Horsepower to drive compressor or blower ..... hp

TABLE 3 ADDITIONAL ITEMS APPLYING ONLY WHEN THE DRIVING ELEMENT IS A STEAM ENGINE

Description, Dimensions, etc., of Compressor Drive

(26) Type of engine (simple or multiple expansion) .....
(27) Type of steam valves .....
(28) Auxiliaries (steam or electric drive) .....
(29) Type and make of condenser equipment .....
(30) Rated capacity of condenser equipment .....
(31) Type of air pump, jacket pump, and reheater pump (direct or independently driven) .....
(32) Type of governing apparatus .....

	1st cyl.	2nd cyl.	3rd cyl.
(33) Diameter of steam cylinders, in			
(34) Stroke of pistons, ft			
(35) Clearance in terms of piston displacement, per cent.			
(c) Clearance, crank end			
(d) Clearance, head end			
(36) Horsepower constant, steam cylinder:			
(a) Head end			
(b) Crank end			
(37) Area of steam-cyl. jacketed surface, sq. ft			
(38) Area of interior surface, sq. ft.			

(39) Steam cylinder ratio (overall):
(a) 1st cylinder to 2nd cylinder .....
(b) 2nd cylinder to 3rd cylinder .....

Average Pressures

(46) Pressure above atmosphere in steam pipe near throttle, by gage ..... lb. per sq. in.
(a) Corresponding absolute pressure ..... lb. per sq. in.
(b) Maximum pressure above atmosphere, steam-pipe diagram near throttle ..... lb. per sq. in.
(c) Minimum pressure above atmosphere, steam-pipe diagram near throttle ..... lb. per sq. in.

	1st cyl.	2d cyl.	3d cyl.
(47) Pressure in steam receiver by gage, lb. per sq. in			

(48) Pressure in exhaust pipe near engine by mercury column ..... in. of mercury
(a) Corresponding absolute pressure ..... lb. per sq. in.
(49) Pressure in jackets and reheater ..... lb. per sq. in.

Average Temperatures

(60) Temperature of steam near throttle ..... deg. fahr.
(61) Temperature of saturated steam near throttle ..... deg. fahr.

(*Continued on page 70*)

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

Experiences on Evaporators with Heat Pumps

By E. WIRTH

THE theoretical bases of evaporation with the heat pump are now fairly well known, but the process itself is still in the early stages of development, notwithstanding the fact that a good many plants have been in operation for a number of years. Up to quite recently data were available only on installations handling liquids with a low boiling point, but today we have other data on the heavier liquids.

The power consumption in the vapor-compression process is determined by the pressure ratio between the vapor-compression chamber and the heating chamber of the evaporator. A part of this pressure difference is consumed by what might be called "dead" temperature head, determined by the rise of the boiling point of the liquid because of the presence of dissolved matter therein. This has been pointed out already by Josse, Fluegel and Schreber. Schreber considers it sufficiently precise to calculate the rise of the boiling point from the content of dissolved matter in the liquid. The writer, however, holds experimental determination to be more reliable, especially as once in his own practice he was unable to obtain proper performance in an evaporator which he built, because the liquid, with constant specific gravity, showed a variation in boiling point as high as 2 deg. cent. This has been confirmed by tests extending over a considerable period of time and without apparent errors in measurement.

The data obtained by direct measurement (Fig. 1) do not show any irregular variations, but produce, in accordance with the specific gravity of the solutions, points lying along two parallel lines, which would indicate the upper and lower limits of boiling. In the case of the glycerine solution, the greatest variation of the boiling point is 2 deg. cent., equivalent to 40 per cent with a total

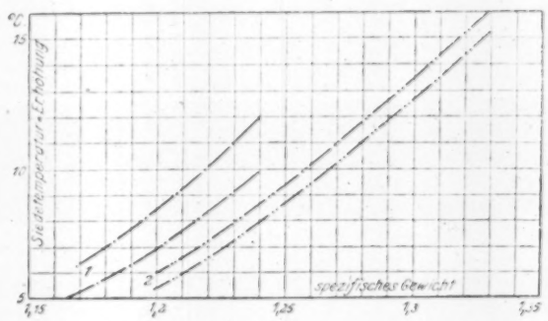

FIG. 1 BOILING-POINT CURVES OF VARIOUS LYES

(*Siedetemperatur-Erhoehung* = rise of boiling point; *Spezifisches Gewicht* = specific gravity.)

temperature head of 5 deg. cent. This is sufficient to cut in half the performance of the evaporator and shift the compressor into the unstable region of "pumping."

Fig. 1 shows not only the variability of the boiling point but also its location as compared with that of pure water. As shown by the curves, the mother liquids can have boiling points 10 deg. cent. (18 deg. fahr.) or more in excess of water, which may make entirely impossible the application of the process. This also shows that evaporator performances of 40 to 85 kg. (88 to 187 lb.) per hp-hr. which have been attained occasionally can be secured only under exceptionally favorable conditions and must not be considered as being possible in general practice.

Useful Temperature Head

In order to show more clearly the movement of the heat the author recommends replacing in the equation for the coefficient of heat transmission $\frac{1}{k} = \frac{1}{\alpha_1} + \frac{1}{\alpha_2} + \frac{\delta}{\lambda}$ the coefficients of heat flow and heat transfer by their reciprocal resistances—

$\frac{1}{k} = w$ = resistance of 1 sq. m. of area of heating element per deg. cent. difference of temperature per hour

$\frac{1}{\alpha_1} = w_1$ = partial resistance on the condensation side

$\frac{1}{\alpha_2} = w_2$ = partial resistance on the evaporator side

$\frac{\delta}{\lambda} = w_3$ = partial resistance of the heater wall.

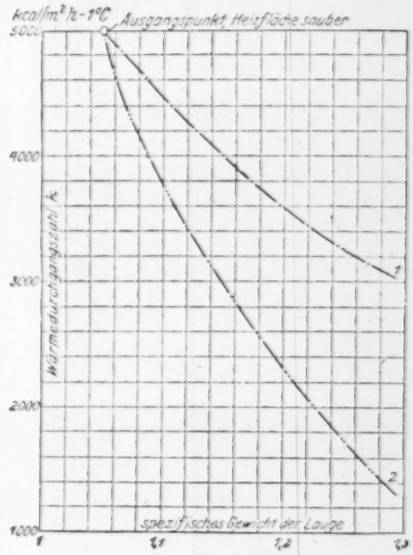

FIG. 2 SULPHITE LYE

(*Ausgangspunkt, Heizflaeche sauber* = starting point, surface of heating elements clean; *Waermedurchgangszahl* = coefficient of heat transmission; *spezifisches Gewicht der Lauge* = specific gravity of the salt solution.)

With this done the total resistance is $w = w_1 + w_2 + w_3$, and the total heat flow is expressed by the equation $Q = \Delta t/w$, similar to the formula for current, $i = e/w$, in electrical engineering.

The partial resistance on the evaporator side may be materially increased by the formation of solid deposits separating out of the mother liquid.

In a certain test there were used in an evaporator first chemically pure non-corrosive sulphite lye and then unpurified lye of similar material, with specific gravities up to 1.3. The heat-transfer values are shown in Fig. 2. From this it would appear that with increasing concentration the heat transfer in the case of pure salt lye decreases, but that the difference in heat transfer is very much greater with unpurified lyes because of an increasing formation of a crust over the heating elements. Notwithstanding the fact that the sediment formation at the end of a 10-hr. run appeared

still to be comparatively light and attacked only a part of the heating element. At the end of the test the coefficient of heat transmission was 3000 for the pure salt solution and 1250 for the impure lye. That the formation of deposits produces unfavorable results in so far as the effectiveness of evaporators is concerned, has been, of course, known for a long time, but it is always assumed that this would apply to very long periods of operation and that cleaning of the tubes would afford a relief for a considerable length of time. The present tests would indicate that this is not always so.

In addition to the maintenance of the walls of the evaporator in a clean condition, the lively movement of liquid in the proximity of the heater walls has also a great influence on partial resistance to heat flow.

The partial resistance on the side where condensation takes

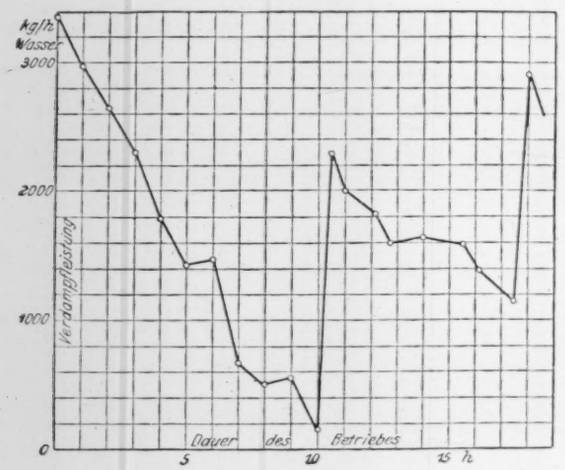

FIG. 3 CURVES SHOWING THE IRREGULARITY OF OPERATION OF AN EVAPORATOR DUE TO DISTURBANCE
(Other than the presence of air arising on the condensation side)
(*Wasser* = water; *Verdampfleistung* = evaporation output; *Dauer des Betriebes* = duration of run.)

place is materially dependent on the presence of non-condensable gases in the steam. For example, the author found by measurement on a vacuum evaporator which was not quite tight that even 3.5 parts per thousand by weight of air in the steam on the condenser outlet side reduces the coefficients of heat transfer from 2140 to 1410. Josse found in the case of a surface condenser that $^1/_2$ of one per cent by weight of air in steam cut the heat transfer as compared with air-free steam in half. It is therefore important to keep the heating chambers as free from air as possible. In the vapor-compressor even a small admixture of air reduces evaporation very rapidly. That not only air but also other gases can affect the heat transfer materially is shown by Fig. 3. The vapor compressor there is operating with the liquid which gives up particles which are, however, soluble in water. Notwithstanding a uniform concentration, uniformly clean surfaces of the heating elements and absence of air, the performance varies to an extraordinary extent, which indicates an unstable condition on the condensation side. Apparently the gas produces an insulating layer on the walls of the heating elements on the condensation side, and this insulating layer upsets all calculations as regards performance.

The partial resistance of the metal walls is the element which admits of the most reliable calculation. It is of importance only in cast-iron evaporators or in evaporators where the resistances w_1 and w_2 are very small. Where chemical influences do not make the employment of other materials imperative, iron is usually suitable for heating elements. If, however, the resistances w_1 and w_2 can be maintained very small, it is of benefit to employ a metal wall of good heat conductivity.

In general, in computing the temperature fall across the heater element, it is better not to assume rigid coefficients of heat transmission, but to consider the character of heat flow in each case and the previous experience available in this connection.

SUPERHEATING OF HEATING STEAM

This has acquired a considerable importance since the employment of compressors which produce superheated steam without any extra cooling. The first experience with compressors proved to be quite difficult, because of the presence of steam superheating, which was generally considered as being harmful to proper heat transfer. On the other hand, however, Classen has pointed out that the heat transfer in an evaporator with superheated steam is, all other conditions being equal, greater than with saturated steam. The experience of the writer would indicate that this is entirely possible, and, on the whole, the influence of superheating of steam need not be always quite as unfavorable as would seem to be indicated by some previous experiments (Ombeck).

Foaming of the liquid, which increases with rise of temperature, may cause trouble, and such means of combating foaming as are known are apt to cause increased pressure losses in the suction piping.

Since a high level of liquid over the heating surface is undesirable from the point of view of evaporating output because it increases the boiling temperature, attempts have been frequently made to combat its influences by the employment of spray devices. This cannot, however, be applied when the liquid is of such character as to form solid deposits. The Piccard process, in which the heating and evaporation are carried out separately and which has been applied as early as 1878 in Switzerland, is fundamentally simple and good, but increases the pressure conditions in the compressor.

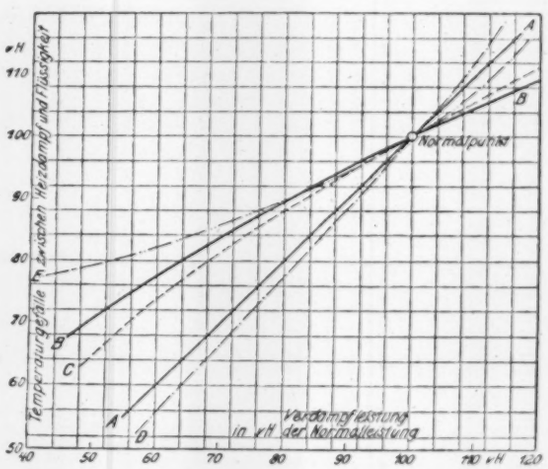

FIG. 4 CHARACTERISTIC CURVES OF VARIOUS EVAPORATORS
(Ordinates: Temperature head between heating steam and liquid; *vH* = per cent. Abscissae: Evaporation output in per cent of normal output; *Normalpunkt* = point of normal performance.)

THE CHARACTERISTIC CURVE OF THE EVAPORATOR

Even with clean surfaces the heat transfer in an evaporator is not of constant magnitude but depends on the type of evaporator, pressure conditions, character of the liquid, and other influences. In the design of the apparatus it is therefore a good plan to plot first the characteristic curve for the evaporator by plotting the evaporator output against the corresponding temperature differences. In order to obtain a general basis for purposes of comparison, there have been used in the curves of Fig. 4 not the actual values but comparative values based on an output of 100 per cent at a temperature difference of 100 per cent.

For purposes of comparison two theoretical characteristic curves have been plotted: *A*, with an entirely uniform rate of heat transfer under which condition the output varies according to a straight-line law with the temperature differences; and *B*, with a rate of transfer which varies in proportion to the temperature fall under which condition the characteristic curve appears as a parabola. Curves *C*, *D* and *E* have been derived from tests on large evaporators and the curve *C* was taken from an evaporator of conventional design with vertical tubes in the heat chamber. It approaches a parabola and the rate of heat transfer appears,

therefore, to be approximately proportional to the temperature fall. Curve *D* is taken from tests by Professor Stodola on a Kummler and Matter compressor, and curve *E* on an evaporator operating with after-evaporation, and therefore one in which the output depends very strongly on the temperature head.

THE COMPRESSOR

For larger outputs on one hand and for higher vacua on the other, only centrifugal compressors can be commercially used owing to the large amounts of steam that have to be handled. Such compressors have a lower efficiency than reciprocating compressors, but they have smaller dimensions and the further advantage that they give oil-free condensate and have and can be coupled to the driving machinery more conveniently.

The centrifugal compressor has a characteristic curve showing that with decrease of volume of steam handled the rise of pressure increases until it reaches a maximum, and then, if the volume of steam continues to decrease, begins to fall off, the compressor gradually passing into the unstable region of "pumping." The compressor operation can be expressed in a percentage curve similar to that used in the case of the evaporator, in which case instead of rise of pressure may be used rise of temperature referred to saturated steam. Fig. 5 gives such a characteristic curve for constant speed in revolutions and constant pressure in the case of a standard Zoelly centrifugal steam condenser having an output of about 1700 cu. m. (60,000 cu. ft.) per hr. and a pressure rise from 1 to 1.7 atmos. abs. The curve *v1* is the characteristic curve obtained without cooling by water injection and curve *v2* with cooling in stages by water injection. Although with cooling by water injection the saturated-steam temperature was about 10 per cent higher, in this particular case cooling did not lead to higher output but only to greater power consumption. Curves *v3* and *v4* give the steam in kilograms per kilowatt-hour of the energy supplied to the driving motor. With decrease of output the evaporation per kilowatt-hour falls off materially, and should this fall below the critical volume it would become necessary to resort to throttling, which would make the efficiency still lower. It would appear, therefore, that for vapor compressors the problem is to arrange matters so as to work always with the compressor at its normal output. (*Zeitschrift des Vereines deutscher Ingenieure*, vol. 65, no. 46, Nov. 12, 1921, pp. 1183–1186, *pe*)

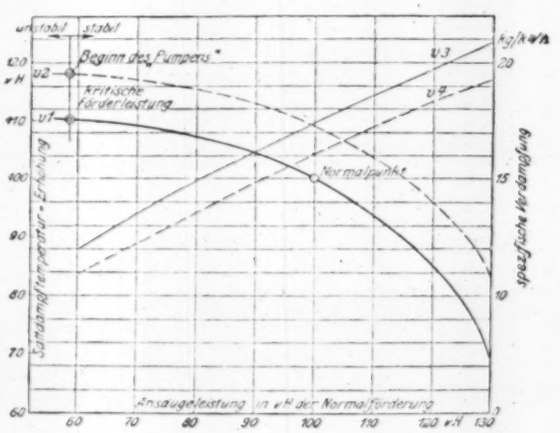

FIG. 5 CHARACTERISTIC CURVES FOR A CENTRIFUGAL COMPRESSOR

(*unstabil-stabil* = unstable-stable; *Beginn des Pumpens* = beginning of "pumping;" *vH* = per cent; *Kritische Foerderleistung* = critical output; *Normalpunkt* = point of normal performance; *spezifische Verdampfung* = specific evaporation; *Ansaugeleistung in vH der Normalfoerderung* = suction output in per cent of normal.)

The following emergency methods for obtaining extra cooling on aeroplane engines are recommended by the Air Board, Ottawa, Canada (Technical Memorandum, No. 12): (1) Addition of a lip to the front of radiator (applicable only to some machines, particularly tractor type); (2) Spiral air deflectors in the open end of the tube (not to be used except for emergency purposes); (3) Removal of cowling (reduces efficiency of engine).

Short Abstracts of the Month

AERONAUTICS

DORNIER DRAGON FLY FLYING BOAT. Description of a new machine built at Rorschach on the Swiss side of Lake Constance by the Dornier Co., a subsidiary of the German Zeppelin Works.

Under the characteristic features may be mentioned the air-flow floats projecting from the sides of the hull, which take the place of the wing-tip floats and have the advantage of contributing to the lift instead of adding to the resistance of the machine.

The machine is built almost entirely of duralumin, which is employed also for the wings and wing coverings. The wings, it may be stated, are of the semi-cantilever type without dihedral or sweepback. They are built up in three sections and are made to fold back, and it is stated that with the wings folded the machine maneuvers on the water as easily as a motor boat.

The outer wing sections are braced to the hull by a pair of streamline struts on each side. When the wings are folded back the front struts are disconnected at the attachment to the hull and are secured to a lug in the lower extremities of the rear struts.

The floating operation can be accomplished in about 1½ min. and it takes only about 1 min. longer to extend the wings. Both operations can be carried out while the boat is on the water and it is claimed that once erected the wings do not require any truing up.

With a 50- to 60-hp. five-cylinder radial air-cooled engine, three passengers on board and fuel for one hour's flight, the machine lifts from the water in about 30 sec. (*Flight*, vol. 13, no. 42/669, Oct. 20, 1921, pp. 685–686, 7 figs., *d*)

AIR MACHINERY (See also Testing and Measurements)

Propeller Blowers

PROPELLER BLOWERS FOR FORCED-DRAFT FURNACES, Werner Mueller. General discussion on the subject of propeller-type blowers as distinguished from centrifugal blowers, and description of some of the German types.

FIG. 1 ALUMINUM-ALLOY PROPELLER FOR USE IN BLOWERS

The design of propeller blowers has been materially affected by information gained from tests on aircraft propellers, as the same aerodynamic laws apply to both, even though the purpose of the two is different.

The essential characteristic of the propeller is the profile with a large cross-section of blade, thick rounded-off entrance edge and smoothly-drawn-out exit edge. The pressure side of the blade is concave and the suction side convex, with the constant curvature so designed as to attain a flow of stream lines as far as possible free of turbulence. Figs. 2 and 3 show the difference in the appearance of the air flow between the correctly selected turbulence-free propeller blade and the common, more or less bent, thin sheet-iron blade. Attention is called in this latter type to the turbulent formations on the suction side, which act as a brake on the wheel and thus create a parasite power consumption. With a blade of proper shape these back eddies do not seem to occur.

In addition to the shape of the blade, the design of the blower housing materially affects its efficiency. The propeller screw acts on the surrounding medium by forcing it ahead acceleratingly, and only to a very small extent does a direct transformation into pressure

take place. Because of this, the velocity to the rear of the propeller wheel is greater than that ahead of it, and in order to secure a flow free from turbulence through the housing this latter must have a smaller cross-section to the rear of the propeller than it does in front of it. (Compare Figs. 4 and 5.) Bendemann shows that theoretically the smallest cross-section should be equal to one-half of the propeller-circle area. With such an arrangement there occurs a clearly defined tightening of the flow lines which decreases in increase in counter pressure but never disappears entirely. The remaining excess in flow velocity can be converted into pressure only by the employment of a conical intermediary piece known as a "diffuser." The diffuser therefore plays the same part in a propeller

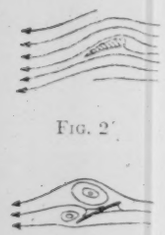

Fig. 2

Fig. 3

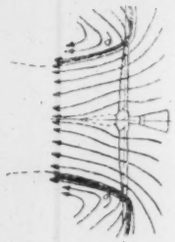

Fig. 4

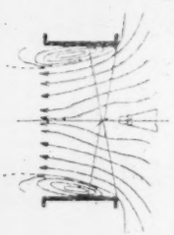

Fig. 5

Fig. 2 Correct Blade Section, Giving a Turbulence-Free Flow

Fig. 3 Incorrect Blade Section, Giving Turbulence in the Rear

Fig. 4 Correct Propeller Housing, Giving Turbulence-Free Flow

Fig. 5 Incorrect Propeller Housing, Creating Considerable Turbulence in the Rear

As to the latter, Fig. 6, in particular, shows that the power consumption of a propeller blower is very nearly the same over the entire cross-section of the piping and that it proportionately falls off as the volume of air increases. It is also practically independent of the resistances which may be created in the piping by the use of throttling valves or similar devices. On the other hand, in centrifugal blowers the power consumption is very materially affected by the presence of resistances, and becomes a maximum with an entirely open pipe cross-section. This means that the motor driving a centrifugal blower has to be made of very generous proportions in order not to be overloaded when all the resistances in the pipe are eliminated; it also means that with certain types of drive, as, for example, the steam turbine, there is a danger that with the passage entirely closed the unit might run away, and special means have to be taken to prevent this dangerous possibility. All these difficulties are eliminated in the propeller blower as the driving motor has to deliver only the predetermined amount of power suitable for continuous operation.

As regards pressure as a function of the pipe cross-section, Fig. 7 gives a straight line, which shows a practically proportional variation. Maximum pressure is obtained with the damper fully closed, while with the damper fully open the entire pressure appears as velocity. Such a mode of variation is particularly acceptable for use with piping, as the pressure produced by the blower increases with the increase of resistances. Contrariwise, in centrifugal blowers the pressure falls off with increase of resistance, which is much less desirable from a practical point of view.

Fig. 8 gives efficiency curves of the two types of blowers, showing

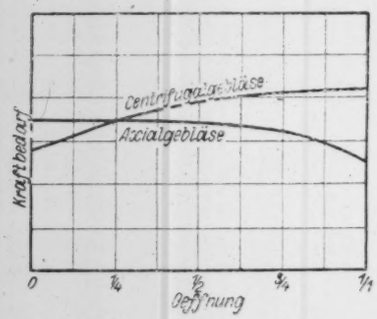

Fig. 6 Power-Consumption Curves for Centrifugal and Propeller Blowers (*Kraftbedarf* = power consumption; *Oeffnung* = free pipe cross-section.)

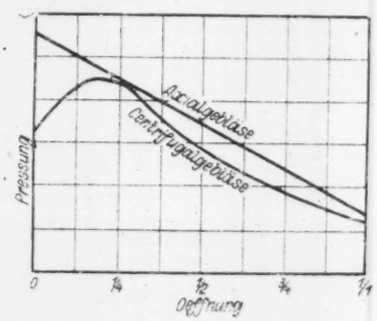

Fig. 7 Pressure Curves for Centrifugal and Propeller Blowers (*Pressung* = pressure.)

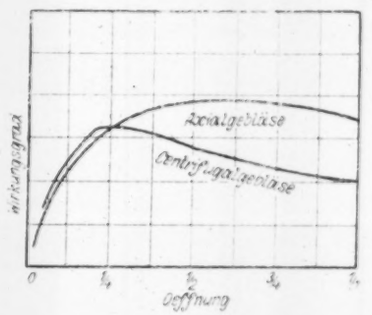

Fig. 8 Efficiency Curves for Centrifugal and Propeller Blowers (*Wirkungsgrad* = efficiency.)

blower as the spiral casing in a centrifugal blower. The relation between the theoretically smallest aerial flow corresponding to the "equivalent nozzle" and the area of the propeller circle gives a valuable basis for the calculation of blowers for given outputs.

As regards the most advantageous speed in revolutions, it is stated that for small blowers 2800 and for larger blowers up to 1450 r.p.m. are best, particularly as they correspond to the usual speeds of polyphase motors, thus permitting direct coupling. Such blowers as the Foege are therefore always built for direct coupling and not for belt drive, as the latter at these high speeds of revolution is not sufficiently reliable. Direct drive through steam or air turbines could also be used.

The propeller proper (Fig. 1) is a high-grade aluminum alloy casting with a tensile strength of 18 to 20 kg. per sq. mm. (26,000 to 28,500 lb. per. sq. in.) and is cast from patterns reproducing carefully-tested-out wooden propellers. It is claimed that these propellers require only a very small amount of machinery, and, in particular, that they do not have to be tested for strength under speeds in excess of operating, as the dimensions are so generously proportioned that there is no danger of their bursting under the action of centrifugal stresses. On the other hand, they must be very carefully balanced, as otherwise heating will develop. Also the boring for the shaft should be done very carefully in order that every blade will travel in the exact path of the preceding blade. Ball bearings exclusively are used, and in addition to a double-row shaft ball bearing a thrust ball bearing is employed.

The article describes in considerable detail some of the features of design and installation of the blowers and also gives data on propeller-blower operation.

that the peak values are about the same in both cases, but the general character of the curves is materially different. In centrifugal blowers the curve of efficiency reaches a clearly pronounced peak value and then rapidly falls off on both sides, which means that it is rather difficult to design a centrifugal blower which will

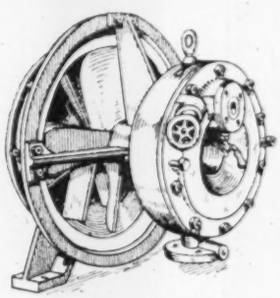

Fig. 9 Forge Blowers

(Translations for all figures: *Oeffnung* = free pipe cross-section; *Centrifugalgeblaese* = centrifugal blowers; *Axialgeblaese* = propeller blowers.)

efficiently take care of the variable local conditions of operation. This is much easier with the propeller blower as its curve is considerably flatter.

Fig. 9 shows, in general outline, a Foege propeller blower. (*Zeitschrift für Dampfkessel und Maschinenbetrieb*, vol. 44, no. 36, Sept. 9, 1921, pp. 281–284, 12 figs., *dce*)

ENGINEERING MATERIALS

Stainless Steel for Turbine Blades

SOME ENGINEERING USES OF STAINLESS STEEL. Stainless steel is an alloy steel containing from 12 to 14 per cent of chromium and about 0.5 to 0.6 per cent carbon. The present paper describes some experiments made with stainless steel in turbine blades, in particular experiments made in a turbine at the power station of one of the makers of this steel.

The machine selected for the test was a British Westinghouse impulse turbine rated at 2000 kw. and running at 3000 r.p.m.

The experimental blades were fitted to two of the wheels some time about June, 1920, and the wheels chosen were, respectively, the velocity wheel which constitutes the first stage of the turbine and is operated with steam at a high temperature, and wheel No. 8, which constitutes the last stage of the turbine and is fed with wet steam. Twelve of the existing blades were removed from wheel No. 8. Three were replaced by highly polished blades of stainless steel having beside them three blades of the same material in the unpolished condition, while on the opposite side of the wheel another

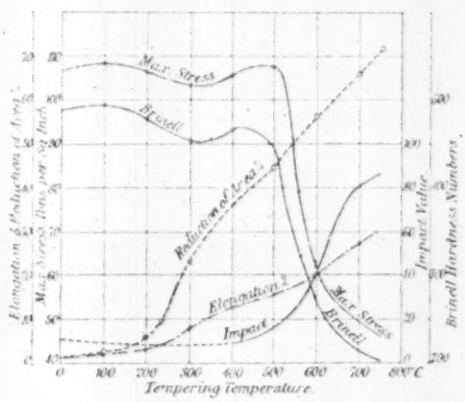

FIG. 10 CURVES SHOWING PHYSICAL PROPERTIES OF STAINLESS STEEL AFTER HEAT TREATMENT

triplet of unpolished stainless steel blades were inserted alongside of three new 5 per cent nickel-steel blades obtained from the builders of the turbine. In the velocity wheel 24 blades were replaced by 21 blades of stainless steel, three of them polished, and by three new blades of the 5 per cent nickel steel.

The turbines were opened up after having been in operation with the new blades for 3471 hr. It is claimed that the stainless-steel blade appeared to be totally unaffected by the work done and did not show either corrosion or appreciable erosion, while the nickel-steel blades inserted at the same time showed both, in particular along the inlet edges. The article refers also to the application of stainless steel to the rams of hydraulic pumps.

In a three-throw hydraulic pump built in Sheffield, rams of stainless steel and phosphor bronze were tried. It is said that the stainless-steel ram has maintained its original polish better and suffered less wear than the phosphor-bronze ram.

Stainless steel can be hardened and tempered similarly to carbon steel, but it is important to note that its change point is much higher, namely, at about 950 deg. cent.

Fig. 10 shows the variation in the properties of stainless steel as tempered at the various temperatures represented by the curves. For forging the temperature should be between 1150 and 900 deg. cent., though it is not impossible to work it below the latter limit. It can be electrically welded, but not with a smith's fire, as layers of chromium oxide form and prevent the union of the surfaces. (*Engineering*, vol. 2913, Oct. 28, 1921, pp. 592-594, 7 figs., *ec*)

STRENGTH OF MANILA ROPE, Ambrose H. Stang and Lory R. Strickenberg. Data of tensile tests of 368 specimens of manila rope. All the rope tested was three-strand, regular-lay type having diameters varying from $^1/_2$ in. to $4^1/_2$ in. An interesting feature of the test is the great consistency in results. The ropes showed, however, a continued varying modulus of elasticity and no well-defined proportional limit.

The following is given as a summary of the results obtained:

1 The average breaking load was found to be approximately a quadratic function of the diameter of the rope. It is expressed quite closely by the equation:

$$L = cd\,(d + 1)$$

in which L is the load in pounds, c is a constant equal to 5000, and d is the diameter of the rope in inches.

2 The ropes showed a continually varying modulus of elasticity and no well-defined proportional limit.

3 The number of yarns composing a rope may be expressed approximately by the equation:

$$N = kd\,(d + 0.4)$$

where N is the number of yarns, k is a constant equal to 50, and d is the diameter of the rope in inches.

4 The test results cover sufficient range and show such consistency that it is believed that the formulas deduced may be used safely for three-strand, regular-lay manila rope for sizes of rope between $^1/_2$ and $4^1/_2$ in. in diameter. (*Technologic Paper of the Bureau of Standards*, no. 198, Sept. 15, 1921, pp. 3-11, 5 figs., *e*)

INTERNAL-COMBUSTION ENGINEERING

An American Solid-Injection Diesel Engine

WORTHINGTON AIRLESS-INJECTION OIL ENGINE. The writer uses the expression "airless injection" to indicate its difference from the air-blast injection of the Diesel engine, although the expressions "solid injection" and "mechanical injection" have hitherto been more common.

In the new Worthington engine fuel oil is delivered to the engine by a service pump operated by an eccentric on the crankshaft.

The engine is of the valveless two-cycle crosshead type with a separate compartment between the cylinder and the crankcase for scavenging air.

One of the distinguishing characteristics of this engine is the use of a divided, or two-part, combustion chamber. The function of this divided combustion chamber is to reduce explosive pressures and to create a condition of air turbulence in the main combustion chamber during the combustion period. Shortly before top dead center, fuel is injected through the spray valve in an atomized condition directly into the smaller of the two compartments, known as the "injection chamber," this being located above and directly in communication with the main combustion chamber or cylinder clearance space. Ignition of the fuel is from the heat of compression and the period of injection is so timed that the partial burning of the fuel charge in the injection chamber produces sufficient pressure to start the flow of the main part of the fuel charge down into the cylinder until the jet of gaseous oil and air from the injection chamber attains considerable velocity, producing a turbulent condition in the cylinder just as the piston starts on its downward stroke. This is accelerated by the downward motion of the piston.

Combustion then takes place in the lower chamber or cylinder, under conditions closely approximating the air-injection Diesel engine, the resultant expansion of gases driving the piston down on its power stroke, after which the cycle described above is again repeated. The pressure from the fuel pump is high, but lasts only during injection about 15 deg. of crank angle. It will be noted that the time and rate of combustion are independent of time and rate of pump injection.

One of the refinements of the Worthington engine consists in providing a scavenging-air connection on the base of the engine which may be piped to the outside of the engine room. By this means a supply of pure, fresh air may be had for scavenging purposes in places where the air of the engine room is charged with dust or explosive vapors.

The fuel-injection pump is of the unpacked type, and as will be seen from Fig. 11, is driven by an eccentric (17) mounted on the crankshaft. Each cylinder has a separate and independent pump, complete in all its details. By avoiding the use of packing from the pump plunger, danger of the plunger sticking is eliminated, and at the same time leakage past the plunger is considerably less than in the usual type of packed pump. The pump body (24) is made from a solid block of steel, designed and constructed with great care, and the plungers and valves are assembled in this body of a unit.

Actuation of the pump plunger is by the eccentric (17), the crosshead (19) engaging the tappet (21), which in turn pushes the plunger upward on its injection stroke, the plunger being returned to its at rest position by the spring as the eccentric passes its top position. The actual instant at which the pump plunger begins to move upward determines the instant of injection of oil into the injection chamber.

For control, a centrifugal governor is fitted, acting through a series of rods and levers to rock the control shaft (10). This shaft is turned eccentric at a point in line with each fuel-pump plunger, and a so-called "by-pass lever" (9), actuated at one end by the pump plunger, rests at the other end on the eccentric part of the control shaft through the medium of an adjustable set screw. As the end of the by-pass lever moves upward with the pump plunger the by-pass tappet (9) and the plunger (7), resting on the lever, will move upward also, closing the gap between its upper end and the suction or by-pass valve (2). When contact is established at this point the continued upward movement of the plunger will

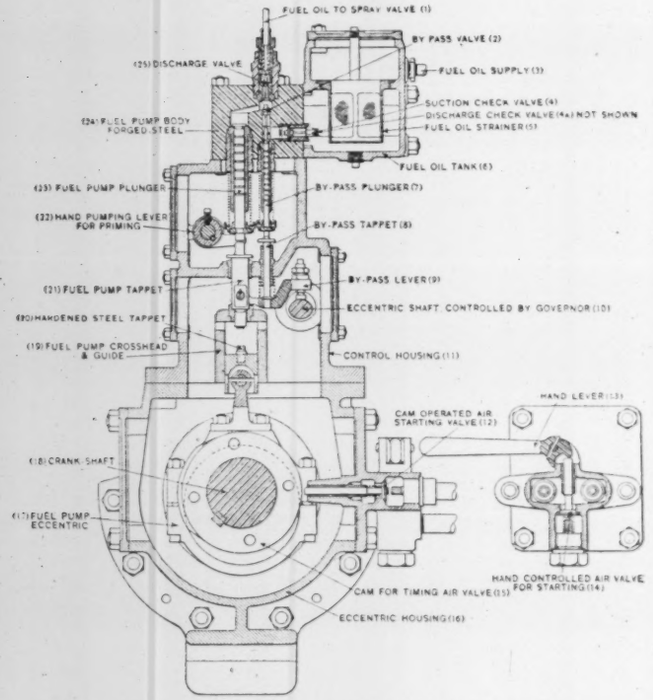
FUEL OIL TO SPRAY VALVE (1)
BY PASS VALVE (2)
(25) DISCHARGE VALVE
FUEL OIL SUPPLY (3)
SUCTION CHECK VALVE (4)
DISCHARGE CHECK VALVE (4a) NOT SHOWN
(24) FUEL PUMP BODY FORGED STEEL
FUEL OIL STRAINER (5)
FUEL OIL TANK (6)
(23) FUEL PUMP PLUNGER
BY-PASS PLUNGER (7)
(22) HAND PUMPING LEVER FOR PRIMING
BY-PASS TAPPET (8)
BY-PASS LEVER (9)
(21) FUEL PUMP TAPPET
(20) HARDENED STEEL TAPPET
ECCENTRIC SHAFT CONTROLLED BY GOVERNOR (10)
(19) FUEL PUMP CROSSHEAD & GUIDE
CONTROL HOUSING (11)
HAND LEVER (13)
CAM OPERATED AIR STARTING VALVE (12)
(18) CRANK SHAFT
(17) FUEL PUMP ECCENTRIC
HAND CONTROLLED AIR VALVE FOR STARTING (14)
CAM FOR TIMING AIR VALVE (15)
ECCENTRIC HOUSING (16)

Fig. 11 Section of Worthington Engine Fuel Pump

open the valve, permitting the oil to by-pass back to the fuel reservoir instead of being forced through the spray valve, and thus ending the injection or effective pump stroke. It will be seen that by rocking the control shaft (10) one way or the other from its normal running position, the instant of opening of the suction valve by the by-pass plunger may be retarded or advanced, thus increasing or decreasing the effective pump stroke and feeding more or less oil into the cylinder, according to the load requirements. Also, by regulation of the set screw in the end of the lever (9), the instant of by-pass opening for each cylinder may be individually adjusted for purposes of initial setting and load balancing. (*Motorship*, vol. 6, no. 11, pp. 872–875, 10 figs., *d*)

Cooling-Water Systems for Stationary Internal-Combustion Engines, Edgar J. Kates, Mem.Am.Soc.M.E. Description of the various systems, beginning with the simple cooling tank and proceeding by gradual stages to the cooling towers of various types, overhead supply tanks, and finally the enclosed cooling system, which is the most modern development.

The principal feature of this latter is that the jacket water is recooled in pipe coils over which other water is showered or flowing. The only place where the engine water is exposed is at the visible outlet. Because of this the loss is negligible, practically no make-up water is required, and clean water may be used for jacket circulation while an inferior type is doing the actual cooling work.

Where there is a scarcity even of inferior water for cooling the pipe coils, an arrangement illustrated in the original article may be used. In this the raw water itself is in a basin below the pipes and pumped by a second pump over an open screen-type cooling tower, where it is recooled and ready to be used again over the pipe coils.

The system just described may seem elaborate and complicated, but it is not so in reality. Where the water available is of inferior character and scarce, as in the mining regions of western Texas, such systems afford the only satisfactory method known of cooling internal-combustion engines. It is said that one oil-pipe-line company has equipped all its plants with similar systems.

Reciprocating pumps are said to be preferable to centrifugal pumps for water-circulating systems, because of their greater reliability and uniformity of operation. (*Power*, vol. 54, no. 19, Nov. 8, 1921, pp. 710–713, 4 figs., *cd*)

LOCOMOTIVE ENGINEERING (See Power-Plant Engineering)

MACHINE DESIGN

The Control of Machines by Perforated Records, Emanuel Scheyer. General discussion of the process as applied to textile machinery, piano players, automatic typewriters, etc.

Perforated-paper-record control has been applied also to metal-working machinery, as, for example, in the automatic multiple-punching machines of Wm. Sellers & Co., described in some detail in the article.

The author proposes to apply a modified form of the Jacquard method of perforated-paper-record control to machine tools of the turret type. He states that a lathe equipped with this kind of control cannot compete with the ordinary cam-controlled automatic lathe within the proper field of work of the latter, but may be applied for handling work which is larger or more complicated than can be handled by cam-controlled machinery. The description of a proposed lathe with such a type of control is given in the original article. (*American Machinist*, vol. 55, no. 19, Nov. 10, 1921, pp. 743–747, 8 figs., *dA*)

MACHINE PARTS (See Machine Tools)

MACHINE TOOLS

Gray Co. Planer with Helical Gear Table Drive. Description of a new planer, one of the characteristic features of which is the use of involute helical gearing for driving the table.

Planers have heretofore been built with herringbone or helical gears for the first reduction, but the new Gray planer has helical gears throughout. The Gray company states that a train of planer gears having one or more pairs of spur gears cannot give the results which are obtained by the use of properly proportioned helical gears throughout, that is, from pulley-shaft pinion to table rack.

Helical gears produce end thrusts. Advantage is taken of this fact to cause the end thrust of the bull gear and its pinion to counteract the side thrust of the tools when cutting. Moreover, the diameters and helical angles of the remaining gears of the train are so proportioned that their end thrusts very largely balance one another. Bronze thrust collars, provided with forced lubrication, take the slight residual end thrusts. Particular attention is called to the helical table rack which is of unusual width of face, giving great strength. The helical rack is arranged so that the end thrust of the bull pinion, which amounts to about one-tenth of the driving force, opposes and compensates for the side thrust of the cutting tools when they are being fed away from the operating side of the machine, a condition which obtains at least 90 per cent of the time. As the tool pressure increases, the power required to drive the table and the resultant balancing thrust of the bull pinion also increase proportionately. This, it is said, equalizes the pressure and wear on the two sides of the V's, whereas with a rack of the spur form the pressure and wear are greater on one side of the V's than on the other, due to the side thrust

of the cutting tools. It also overcomes the tendency of the tools to push the table up the side of the V's.

To provide correct tool action, teeth of true involute form, cut by a generating process, are employed. In order to avoid interference and imperfect tooth forms, and to obtain great smoothness of action and stronger teeth, the pinion teeth are so cut that the greater part of the tooth face lies outside the pitch circle. The teeth have a low pressure angle, are cut full depth, and have a short arc of approach and long arc of recess, giving high efficiency, and greatly increasing the number of teeth in contact and the smoothness of action. The action of a tooth having a long arc of recess compared to one with a long arc of approach is analogous to the action of dragging the end of a pole behind you compared to pushing it ahead of you.

This design, it is said, also has the advantage of permitting the use of pinions of larger diameters and stronger tooth form without the disadvantage which attend the use of stubbed teeth, high pressure angles and low gear ratios. (*The Iron Age*, vol. 108, no. 22, Dec. 1, 1921, pp. 1417–1419, 4 figs., *d*)

MECHANICS

STRESS COEFFICIENT FOR LARGE HORIZONTAL PIPES, Jas. M. Paris. A new method of calculating stresses wherein a general case of the pipe is analyzed by breaking it up into a number of fixed elementary cases, and elastic analysis for each of these is worked out, the results being then combined by simple addition in proportion as the several elementary loadings are contained in the actual loading of any given particular case.

Essentially, for general loads on a large circular pipe, it is assumed that the deflection along the vertical diameter takes place at one end. Considering the half-pipe to one side of this diameter, its one end is assumed fixed and the half-pipe treated as a cantilever beam; the very end is imagined to deflect under the applied external loads and then brought back to its original direction by a moment applied through M_T, and back to its original position by a horizontal force H_T.

From the elastic-arch theory, using Maxwell's theory of reciprocal deflections, equations are deduced for the unknown reactions M and H. These reactions contain m, which is the general expression for the cantilever moment of the external forces on either half of the pipe, and by substituting for m in the equations its actual value for any loading, values of M_T, H_T, etc., are found for that loading. When this has been done for various simple and elementary loadings, any number of them may be combined, and by addition of the separate values the resultant value of H_T or M_T may be found.

Several interesting examples of the application of the method are given in the original article. (*Engineering News-Record*, vol. 87, no. 19, Nov. 10, 1921, pp. 768–771, 3 figs., *tA*)

THE WHIRLING SPEEDS OF A LOADED SHAFT SUPPORTED IN THREE BEARINGS, Prof. H. H. Jeffcott. An extensive paper dealing analytically with the first and higher whirling speeds of a shaft supported in three bearings loaded in any manner and of sections varying from place to place along the length of the shaft. In the general case the shaft is supposed to change in diameter at various sections along its length and to be of uniform size between such sections. Other assumptions are made, in particular, that the shaft is assumed to carry at various places along it a series of loads each of which is balanced. The bearings are assumed to act as free supports and not to fix the direction of the shaft any extent for the small deflections contemplated.

In solving the general problem of a number of loads on the shaft, the author resorts to the use of a principle originally enunciated by Bresse, which may be stated as follows: The displacement of any point by reason of the deflection of the shaft is the resultant of the displacements which would be produced if one supposes all the external known forces to act separately, and one after the other. Thus, the shaft may be considered as supported at each end under the action of the given load acting downward, and also under the action of the supporting force at the intermediate bearing acting upward. The result of the action of these two systems of forces is to make the deflection zero at the intermediate bearing.

From this the author derives a number of equations for the deflections and slopes at any given point of each span due to the system of loads and for the total deflection and slope due to all the loads acting simultaneously. A numerical example to illustrate this principle is given, as well as equations determining deflections and slope under the centrifugal loading considered.

One simple case of oscillatory vibration for a three-bearing shaft is considered and the speed of a simple oscillatory vibration determined, likewise the ratio of oscillatory speed to normal whirl speed. (*The London, Edinburgh and Dublin Philosophical Magazine and Journal of Science*, vol. 42, no. 251, Nov. 1921, pp. 635–668, 5 figs., *tm.A*)

MEASUREMENTS AND TESTS (See Engineering Materials)

MILITARY ENGINEERING (See also Aeronautics)

AIRCRAFT VERSUS DREADNAUGHTS, Hon. Frederick C. Hicks. General discussion of the part of aircraft-bombing tests of seacraft which closed with the sinking of the *Ostfriesland*, presented in a speech in the House of Rrepresentatives, of which the author is a member.

The author tries to present both sides of the question and points out that as long as gravity is the force utilized to carry the bomb to the target, an aeroplane will always have to be within a certain fairly limited zone over the ship which it is attacking.

On the other hand, however, the torpedo-carrying plane may be expected in the near future to become part of the aircraft outfit, and the torpedo bids fair to be the most deadly weapon carried by aircraft.

As regards the effectiveness of bombs which would simply hit the superstructure, it is admitted that they smash things badly, but it is believed that their destructive effect is largely local. In fact, what happened on the destroyer *Manly* in 1918 when a number of depth charges exploded on her afterdeck, it would appear that bombing on decks would not materially affect the men below, though of course it is always possible that a bomb might jam the rudder, derange the alignment of the shafts, or cause other damage that would affect the steaming or maneuvering capacity of the ship.

Of the lessons taught by the demonstration the following might be cited.

1 Aircraft is a weapon of such great value as to warrant the immediate expansion of the service; among other things, by the construction of aeroplane-carrier vessels of large size and great speed. No need in the United States Army is said to equal today that for ships of this type, of which there is none either built, building or authorized.

2 For coast defense, aeroplanes are indispensable and are weapons of the first magnitude.

3 Heavy bombs should be employed from the very outset of the attack, except in special cases.

4 Close-by, under-water hits are more deadly than direct hits on the decks or hits on the surface of the water. Under-water explosions can be obtained by delayed fuse action, and, as a matter of fact, the heavy bombs had a delayed action of $1^1/_5$ sec.

5 There must be a change in the design of surface craft with increased watertight integrity, and war vessels must be provided with better means of protection from both explosive and gas bombs.

At the same time the speaker pointed out that aviation is in its infancy, while battleship construction represents the advanced thought and skill of a century. The margin of development undoubtedly lies with a new service. (*Journal of the United States Artillery*, vol. 55, no. 5/183, Nov. 1921, pp. 390–399, *g*)

MOTOR-CAR ENGINEERING

BRITISH 200-MILE RATE AND ITS LESSONS, "A Competitor." One of the striking features of the British 200-mile race limited to cars of 1500 cu. cm. was the high crankshaft speed employed and the reliability of the multi-valve head. Speeds were as high as 4000 r.p.m. (*The Autocar*, vol. 47, no. 1359, Nov. 5, 1921, pp. 864–865, *g*)

PROGRESS IN LIGHT CARS, "Runabout." The success of some small cars in the Scottish six-day trial and their ability to handle all requirements of general travel have led to what appears to be

a stampede to produce cheaper and lighter cars, and a good many of them appear to be quite satisfactory.

Some of these cars like the 8-hp. air-cooled Rover have given apparently excellent satisfaction. It is, however, stated that air cooling is still in its infancy and, for example, the Rover has to be decarbonized about every 800 miles. Also the twin-cylinder engine is apt to be somewhat noisy. Improvement is, however, being rapidly made in both directions.

As regards performance, it is stated, for example, that a speed Hillman does 45 m.p.h. uphill on middle gear and is very economical both in oil and fuel consumption.

An important feature in this connection is that not only the smaller firms but also some of the leading concerns are becoming effectively interested in the production of small cars.

As regards the economy of the small cars, it is stated that 35 miles per gallon is common and as high as 50 miles has been attained, together with 1500 miles per gallon of oil. At the same time, however, it should be remembered that the cost of running a small car is very much higher in England than it is in America. In the first place, a car of the Hillman type costs somewhere around £400, or roughly $1500, although 8-hp. models are available in the market at prices as low for British conditions as £250 ($950). (*The Autocar*, vol. 47, no. 1359, Nov. 5, 1921, pp. 879–882, 6 figs., *g*)

General Survey of the Mechanical Features of British Automobiles for 1922. An article based on the features shown at the Annual Automobile Exhibition in London. In the broadest sense, the typical car of 1922 as exemplified by the show meets the following specifications: Four-cylinder water-cooled block engine with side valves; magneto ignition; cone clutch; four-speed side-chain gear box; spiral bevel final drive; semi-elliptic springs; wire wheels.

There is, however, a strong tendency toward the use of overhead valves, detachable cylinder head, single-plate clutch, disk wheels and possibly four-wheel brakes.

The four-cylinder engines still hold the leading position; detachable cylinder heads are becoming common practice, and the joints are being so arranged that the gasket has to be compression type only, while separate joints, sometimes in the exterior of the engine, attend to the necessary water circulation between cylinder jacket and head jacket.

Water cooling remains standard for the engines of larger cars, but air cooling for smaller vehicles is used and a new system of air cooling has made its appearance. As regards air-cooled engines, it has been found that the cylinders become rapidly carbonized with burned oil. Also an excess of oil in the combustion chamber is a prolific source of spark-plug troubles.

In one car this year there is used an engine which is oil-cooled, the method being to increase to about double the quantity of oil carried and to give it a free circulation over the outside of the cylinder walls, the outside of the valve seats, the valve stems and springs, the inside walls of the cylinders and the interior surfaces of the pistons. Preliminary tests have been satisfactory.

Cast iron appears still to be the favorite material for pistons. Of late there has been a tendency to decrease the thickness of piston rings and it is becoming common to use for narrow rings fitted to each piston, three compression rings at the top and a scraper ring at the bottom of the skirt.

As regards valves, the use of multiple valves has not made much progress in touring-car engines. Overhead valves are, however, steadily gaining in popularity, especially on engines of small cubical capacity.

Skew gears and spiral bevel gears are used, but the production of a gearing sufficiently quiet and inexpensive is a matter which taxes the ingenuity of engineers. The regular practice is to use an overhead valve gear operated by push rods from a camshaft containing in the crankcase, which is easier to manufacture commercially.

In regard to lubrication and carburation, the situation in England appears to be essentially the same as in America.

The outstanding feature in brake design is the introduction of front-wheel and four-wheel systems. It is only questions of expense that retard the adoption of front-wheel brakes for the less expensive cars, but much experimenting is in progress. In most cars where the open propeller shaft is used, the transmission brake is employed; also opinion is veering round to the idea that a compensating device is not necessary for rear-wheel brakes, but that some form of linkage which allows a slight spring is effective and less liable to get out of order.

Disk wheels are making steady progress, owing to the fact that they can be produced cheaply and are very easy to keep clean. Most of the small cars are now fitted with disk wheels, the sole objection being their liability to exaggerate any noise emitted by the back axle. (*The Autocar*, vol. 47, no. 1360, Nov. 12, 1921, pp. 945–953, illustrated, *g*)

PIPE (See Mechanics)

POWER-PLANT ENGINEERING (See also Air Machinery)

Preheating Air to Furnace by Flue Gases, E. R. Welles, Mem. Am.Soc.M.E., and C. T. Mitchell. The problem as to whether air delivered to furnaces can or cannot be preheated by flue gases is more an economic than a mechanical one, the chief concern being to find how large an apparatus can be built and still obtain a reasonable return on the investment.

Economy from preheating air would manifest itself in reducing coal consumption per unit of power output, as such coal would be needed to preheat the air in the furnace. In other words, the beginning of the heat cycle would be moved up a notch.

In regard to the furnace control with hot air, there is the choice of two courses. The quantity of air can be reduced in proportion to the reduction of coal, thus raising the furnace temperatures and probably lowering the stack temperatures. All conditions can be maintained as they were with cold air, using enough warm air to keep the furnace temperatures, and hence also the stack temperatures, unchanged.

From such evidence as the authors have we should expect no trouble regarding furnace control, but a greater tendency to burn out the grates and tuyeres, increasing with the temperature of the air.

Preheating would be particularly helpful with powdered coal and would immediately widen its field of application.

In order to determine the economical size of a preheater, the writers attempt to develop an expression for the efficiency of such a unit for varying capacity of heating surface. To do this they assume that the heat-transfer apparatus consists of a sheet-metal condenser filled with steel tubes. The flue gas travels through the tubes and the cold air around the tubes, or vice versa, the flow being countercurrent in order to keep the temperature difference nearly constant. The weight of the flue gas per hour is taken the same as the weight of air and the velocity of the two and specific heat are the same, the latter being 0.25. The final formula for the efficiency of the heater under these assumptions is—

$$\frac{1}{\frac{W}{2AK}+1}$$

where W = lb. of air per hr.; A = heating surface of the preheater in sq. ft.; and K = heat-transfer rate in B.t.u. per sq. ft. per hr. per degree temperature difference between the surface of the tube and the adjacent air. (This quantity must also take care of any mechanical or structural limitations in the heater.) The proper value for K here is of determining influence and yet it is still quite uncertain, and all things considered the writers expect the value of K in a properly designed heating unit to be not less than 4 and possibly as high as 10. From this point of view the diagrams in Fig. 12 become of interest. Each curve has a point of greatest curvature and it is to be anticipated by the correct size of the heater for any given set of conditions will lie approximately under that point. If we know the cost of heaters per square foot and also the true value of K, it becomes a simple matter to determine the size of heater giving the greatest net return on the investment.

A numerical example is given in the original article. The entire matter seems to be yet in the initial stages of development, and as an editorial in the same issue of *Power* (p. 84) points out, the commercial success of an air preheater is still uncertain. (*Power*, vol. 54, no. 22, Nov. 29, 1921, pp. 844–846, 1 fig., *dg*)

THE DESIGN OF AN INTERNALLY FIRED SUPERHEATER, Prof. W. R. Woolrich, Mem.Am.Soc.M.E. Some data of work done along these lines at the University of Tennessee. Experiments were tried as early as 1910 at the University of Tennessee to superheat steam by the combustion of gas, the burner operating within the steam main against the steam-main pressure. In 1916–17 a design was assembled by the author. Fundamentally, the apparatus consisted of a commercial air-atomizing oil burner designed for high pressures with its tip projecting into the steam pipe. In actual tests with a burner ignited and the steam line closed, it was found that no adjustment would give a suitable flame at the burner tip and as soon as the outside supply of air was shut off the flame would go out. This was because the commercial oil burner is designed to secure only a part of its air supply from the inside, replying on the surrounding air to make up the deficiency.

In 1919 H. E. Ayres took up the problem as an undergraduate thesis. In this case a new burner was made up representing a combination of two standard oxy-acetylene welding torches with several added features.

This work was continued by O. A. Kraehenbuehk, but the results at first were very unsatisfactory. No difficulty was experienced operating the burner in the closed main without steam, but when the steam was turned on at any working pressure the flame would be extinguished.

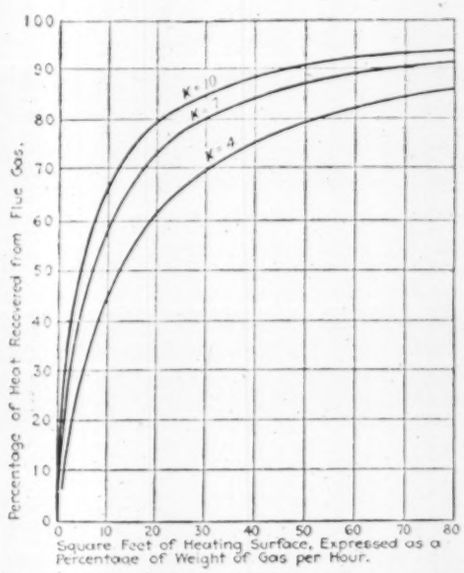

FIG. 12 CURVES SHOWING RELATION BETWEEN SIZE OF AIR PREHEATER AND RECOVERY OF HEAT IN FLUE GAS (*K*-HEAT-TRANSFER RATE)

After a series of adjustments operation was secured but of a very erratic character, the burner at times working steadily for periods as long as an hour. On the whole it has been proved that gas can be burned in the presence of high-pressure steam, but the influence of non-condensable by-products supplied to the steam by these means on condensation has not been determined.

The method may be applicable, however, to superheating of exhaust steam to be used in dye tubs, laundries, and, generally, processes where steam temperatures over 212 deg. fahr. are required. (*Power*, vol. 54, no. 19, Nov. 8, 1921, pp. 717–718, 2 figs., *d*)

Waste-Steam Turbine at Coal Mine

MIXED-PRESSURE TURBINE INSTALLATION WITH A REGENERATOR AT A COAL MINE, C. W. Smith. Description of the power plant recently installed at the Nokomis Mine in Illinois.

Prior to the installation of the plant all electric power used was purchased from outside, while the hoist, fan engine and several pumps were supplied by steam from six horizontal return-tubular boilers. This system resulted in very high operating costs for power, especially during periods of slack work. The costs have increased still more in the last two years when the power companies' rates were almost doubled. Another objection to this system of operation was the numerous and expensive shutdowns caused by frequent failures of the utility plant to deliver current.

Because of this it was decided to install a power plant sufficient to take care of all requirements. In order to conserve steam it was decided to electrify all machinery on the surface with the exception of three car-puller engines. This not only decreased steam consumption generally but reduced condensation in the various steam lines.

In order to utilize the waste steam from the hoist engine a mixed-pressure turbine was selected for the main unit of 1000 kw. capacity, in addition to which a 300-kw. high-pressure turbine was installed to handle the night load.

The system is as follows: The exhaust steam as it comes from the hoist engine passes through an 18-in. header to the Rateau regenerator. This is 9 ft. in diameter and 25 ft. long and is equipped with back-pressure valves set at 3 lb., which is the maximum back pressure on the hoist engine. From the regenerator the exhaust steam passes through an oil separator to the low-pressure side of the turbine. When the pressure in the regenerator falls to about 1.5 lb. per sq. in. below the atmospheric pressure, the governor on the mixed-pressure turbine automatically admits enough live steam to carry the load until the pressure in the regenerator is again sufficient to carry the load alone. The 300-kw. high-pressure turbine is equipped with a jet condenser. The circulating water from this condenser is not passed through the spray nozzles handling the cooling water on the main condenser, as this would require an additional circulating pump. This cooling water is allowed to circulate from the discharge near one end of the pond to the suction line on the opposite end. During the normal operation for which this unit was intended this arrangement is entirely satisfactory. Even in the summer months the temperature of the pond rises only a few degrees. When this unit has to be operated for more than 16 hr. a day, as sometimes happens when the mine is not working, the circulating pump on the large condenser is operated once or twice a day for a period of approximately an hour in order to cool down the temperature of the pond. This has proved a highly satisfactory manner of eliminating an additional circulating pump and of saving the power required for its operation.

It is stated that no trouble has been encountered as regards the performance of the mixed-pressure turbine in shifting from high-pressure to low-pressure steam under variable loads. It has also been found that the regenerator instead of increasing the back pressure on the hoisting engine has caused it to be reduced. However, the original exhaust lines were too small. Under conditions existing at the Nokomis Mine only two men have had to be added to the power-plant force since this plant was put into operation.

The installation is of considerable interest to deep-shaft mine engineers. The steam hoist has been considered rather wasteful to operate, and if this wastefulness can be overcome by the installation of a mixed-pressure power plant, this would tend to increase materially the field of usefulness of this latter. (*Coal Age*, vol. 20, no. 19, Nov. 10, 1921, pp. 753–757, 7 figs., *d*)

PUMPS

Centrifugal Pumps in Sugar Refineries

CENTRIFUGAL PUMPS IN SUGAR REFINERY, Claude C. Brown, Mem.Am.Soc.M.E. For various reasons motor-driven centrifugal pumps are rapidly growing in favor in sugar-refining work, but the type of pump used has some special features developed to meet sugar needs and conditions.

In Western sugar-refining plants where great quantities of salt water are used for condensing purposes in connection with the boiling of sugar in vacuum pans, the pumps are situated on the ground floor of the plant where they have a suction lift from the bay of from 12 to 15 ft. according to the tide and a lift of approximately 150 ft. to the pan condensers. When first installed trouble developed. Thus, it was difficult to hold the suction at low tide, as air was finding its way into the pump suction. The introduction of this air was eliminated by tightening all leaks in the suction line, smoothing it out and eliminating air pockets and sharp turns. Furthermore, it was found that at the points in the casing casting adjacent to the runner hub there were shoulders which still continued to act as air pockets. These shoulders were vented to the outer casing with a $^1/_8$-in. line which effectually destroyed any detrimental effect they might have had.

The method of priming these pumps is of interest. A small vacuum pump was installed near the battery of pumps and a $^1/_2$-in. line run to each pump. When it is desired to start one of the centrifugal pumps, the small vacuum pump is started first and any number of salt-water pumps can be primed immediately.

As first installed the salt-water pumps consisted of cast-iron casings with bronze and cast-iron runners and shafts made of Cumberland steel. Before very long powerful corrosion set in, affecting both casing and runner. The cast-iron casing was then replaced by a bronze casing, and the Cumberland steel shafts by shafts of 3 per cent rolled nickel steel. Further, bronze sleeves were shrunk on over the portions of the shaft that were inside the pump, after which all trouble from corrosion disappeared.

For the pumping of liquors, syrups, etc., other questions of corrosion and erosion came up. Here again the most successful results were obtained with combinations of bronze casing, bronze runner, and steel shaft with bronze bushing. This withstood

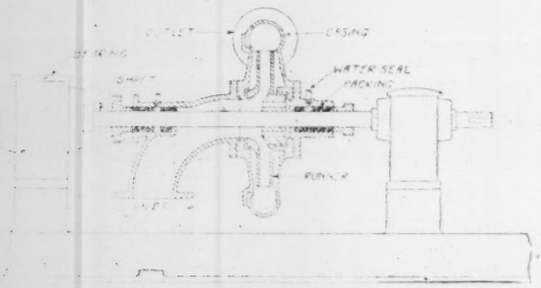

Fig. 13 Centrifugal Pump with Water-Sealed Packing for Pumping Sugar Solution

corrosion but not erosion, and where this latter was especially noticeable, cast-iron casing, chrome-vanadium steel runner and monel-metal shaft were used which gave good satisfaction.

In the pumping of sugar solution it is absolutely necessary that this latter shall not come in contact with the pump packing. Because of this water-sealed packing (Fig. 13) is used. A $^1/_4$-in. line of fresh water is connected within each packing gland and just

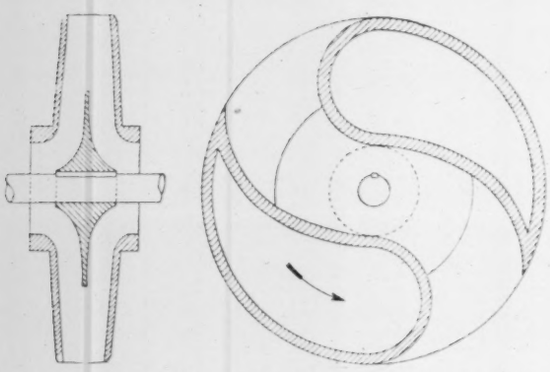

Fig. 14 Sewage-Type Runner with Double Suction

enough water allowed to enter the gland to seal it and prevent the sugar from coming out.

As regards the question of type of pump runner, it has been found in sugar plants that the most successful type for general all-round requirements is the sewage-type runner (Fig. 14). The open-type runner, which resembles an open star, has also proved successful, particularly for pumping liquids which have matter in suspension. (*Power Plant Engineering*, vol. 25, no. 22, Nov. 15, 1921, pp. 1087–1088, 4 figs., *d*)

SPECIAL MACHINERY

Bar Mills Adapted to Handle Alloy Steel, J. D. Knox. Description of a new unit built by the Central Steel Company, Massillon, Ohio, the characteristic feature of which is that care has been taken to adapt the mill to peculiarities of alloy steel. Only some of the features can be noted here. Thus, the motors driving the 16- and 12-in. roll trains are cooled by air washed in a Carrier-type washer.

The 18-in. finishing mill is driven by a 2200-hp. variable-speed motor designed to operate from 303 to 505 r.p.m. The gear set with a ratio of 115 to 34 provides various roll speeds ranging from 90 to 150 r.p.m. (*Iron Trade Review*, vol. 69, no. 20, Nov. 17, 1921, pp. 1275–1281, 11 figs., *d*)

SPECIAL PROCESSES

Bending Lock-Seam Tubing. Lock-seam tubing is made with the folded seam. Such tubing can be used for automotive exhaust manifolds providing it can be bent to the forms required for this purpose without opening the seams. The method of making the bends by first filling the tubing with molded lead or rosin was found, however, to be too expensive for commercial production.

In order to meet this problem a special form was made for use on a No. 5 pipe-bending machine by the Wallace Supply Manufacturing Co. of Chicago, Ill. This equipment is so designed that the work is continually supported around the complete circle both inside and outside at the point of bending. The form around which the work is bent is grooved to embrace half the circumference of the pipe and a similar grooved follower embraces the other half of the pipe. There is a mandrel of the same size as the inside diameter of the work to be bent. As the pipe is bent around the form both the follower and mandrel move with it, so that they always support the work at the point of bending and the metal is made to flow. (*Machinery*, vol. 28, no. 4, December 1921, pp. 289, *d*)

STEAM ENGINEERING (See also Engineering Materials)

Investigation of Breakdown of 30,000-Kw. Turbine. Data of an investigation by Prof. H. F. Moore, Mem.Am.Soc.M.E., and Geo. L. Kelley of the accident to the 30,000-kw. turbine of the Philadelphia Electric Co. which occurred on Saturday morning, Sept. 3, 1921.

The machine was being tested for overspeed and was gradually brought to 9 per cent above its normal speed of 1500 r.p.m.; the throttle was then closed by the governor, and the machine began to slow down. A few seconds after the main throttle had closed a loud hissing noise was heard, instantly followed by two heavy crashes and a shower of broken pieces of metal.

The investigation has shown that the low-pressure casing was cracked, the steam passages from the high- to the low-pressure stages were broken, all the shaft bearings were broken and the 20-in. mainshaft likwise.

The following explaaation is offered by Professor Moore: Under running conditions the passage from the high-pressure to low-pressure stages is under a bursting pressure considerably greater in magnitude than the collapsing pressure existing when there is a vacuum in the passage, and moreover the casting is designed with stiffening ribs on the outside, so that under bursting pressure the bulging of the passage will tend to cause the ribs to be in tension in their outer fibers and the plates to be in compression. Under vacuum this state of affairs would be reversed. He believes, therefore, that it would seem unlikely that the steam-passage casting would fail when the interior was under vacuum and the fractures are explained as secondary failures.

One of the most striking features of the wreck was the breaking of the mainshaft and the tearing up of the surface of the exciter armature. The character of the metal at the break would lead one to believe that there was dragging of one piece of metal over the other as fracture occurred.

As regards the primary cause of failure, a theory was offered to the effect that a polepiece of the exciter field became loose and was jammed into the armature, causing enough twisting or bending to break off the exciter frame and the main shaft, throwing the remainder of the shaft sufficiently out of line to cause the wreck of the turbine disk and bearing. The state of the armature would appear to support this theory.

From all evidence it would appear that the failure of the main shaft was one of the last events in the wreck.

The fractures in the turbine disk show evidence of a progressive crack ascribed to the existence of lateral vibrations in the disk. This again is explained as follows: The steam jet enters on one side of the buckets and leaves from the opposite side, any frictional lateral drag from the steam being all the time in one direction. As the disk revolves the steam must strike on any given blade with a regular rhythmical variation of force. At certain speeds this rhythmical variation might be so nearly in tune with the natural period of lateral vibration for the disk that severe repeated bending stresses would be set up. Moreover, these lateral vibrations may have been numerous enough to develop such a typical progressive fracture as was found in this case.

In addition, it was found that the turbine disk had only a rough surface finish and carried deep tool marks which might have served to localize the effects due to sidewise vibration. In fact, recent tests at the University of Illinois made in the course of the joint investigation on fatigue of metals have shown that such surface conditions might reduce the ability of the disk to resist lateral vibrations by as much as 20 per cent.

If the primary cause of the wreck were a progressive failure of the disk, it is easy to show that the wreck might be expected to occur at a time when for any reason the speed is particularly high. In this instance, for test purposes the speed was increased to 109 per cent of its normal magnitude which resulted in an increase of centrifugal force to 1.19 times its normal value, which is a very material increase indeed. (*Power*, vol. 54, no. 21, Nov. 22, 1921, pp. 788–793, 13 figs., *dg*)

STEAM TURBINES (See Mechanics)

SUGAR REFINERY (See Pumps)

TESTING AND MEASUREMENTS

MEASUREMENT OF AIR VELOCITIES AND THE TESTING OF ANEMOMETERS, Jas. Cooper. The two best-known methods of measuring air velocity in mines, namely, by the anemometer and by means of smoke, are both liable to serious error. In particular, as regards anemometers, the friction of the parts has the effect of making anemometer readings correct for only one particular velocity. At other velocities accuracy can be achieved only by corrections for the influence of friction, and at low velocities the corrections may be greater than the speed registered by the instrument.

In view of this, means for testing anemometers have been provided at the Heriot Watt College in Edinburgh. There is already in England an installation for testing anemometers at the National Physical Laboratory, but they are not tested there at velocities lower than 600 ft. per min., while air speeds under that figure are common in mines and the need for calibration is particularly imperative for velocities below 300 ft. per min. The testing table used for calibrating anemometers is described and it is stated that figures obtained from the tests have been compared, first, by observation of smoke velocities, and second, by walking tests with the meters over a measured straight line in a still atmosphere.

The data of tests were charted and it was found that although the charts plotted from the tests were similar in form to those sent out by the makers of the instruments, the figures of correction varied widely. (Paper presented in October, 1921, before the Mining Institute of Scotland, abstracted through *The Iron and Coal Trades Review*, vol. 103, no. 2798, Oct. 14, 1921, p. 540, *ep*)

Friction of Cup-Leather Sleeves

TESTS ON CAP-LEATHER SLEEVE FRICTION, Eugen Irlon. In the measurement of power in testing materials with machines operated by means of levers or weights or the like, precision to within 1 per cent is usually obtainable with comparative ease. On the other hand, when the power is applied by hydraulic means, its measurement is complicated by the fact that considerable friction is present at the cup-leather sleeve, depending on the fluid employed as a pressure medium and the material of the packing, and therefore subject to considerable variation. As a matter of fact, unless this friction is measured quite frequently, considerable errors in final results of measurement of power applied may be found. Data of such tests of friction in cup-leather sleeves are presented in this article. All the data in the abstract will be given in the original metric units and the conversion factors to American units appended in a note at the end of the abstract.

This is not the first attempt to measure such friction and an investigation on the same subject has been published by A. Martens in the *Zeitschrift des Vereines deutscher Ingenieure*, 1907, p. 1184.

The present tests were carried out in a 75-ton hydraulic bending machine water-driven by a three-piston electric pump. The pressure cylinder had a useful piston area $F = 380.13$ sq. cm. (58 sq. in.) The dial of the pressure gage was graduated in atmospheres and kilograms.

The division into kilograms was obtained experimentally by using the average friction value obtained by Martens and by adding this value to the pressure in kilograms as obtained from the equation—

$$P = Fp \qquad (1)$$

where P is the theoretical pressure, F the piston cross-section in square centimeters and p the pressure in the pressure cylinder in kilograms per square centimeter. This gave Equation (1) the form—

$$P_1 = (F\,p + F\,\frac{pR_\rho}{100}) = Fp\ (1 + \frac{R_\rho}{100}) \text{ in kg} \qquad (2)$$

where P_1 is the actual pressure in kilograms, and R_ρ the cup-leather sleeve friction in per cent as found by Martens.

The total friction was measured by a special gage having a maximum range of 100 (metric) tons (=110 short tons). Two other pressure gages were used with ranges of 100 tons and 200 tons, respectively, the errors of which were determined by careful calibration. Table 1 gives the friction values found by Martens in 1907 as percentages of the pressure in kilograms per square centimeter. The values in column 2 have been calibrated from Equation (1), and the values in columns 3 and 4 taken directly from the tests of Martens. By adding the values in columns 2 and 4 are obtained the values of column 5 giving a total effective pressure p_1 in the pressure cylinder in kilograms per square centimeter.

The tests have shown, as is evident from Table 2, that the differences between the actual experimental data as shown by the gage and the values in the curve of Martens (curve *A*, Fig. 15) in ordinary cases do not amount to more than 0.5 to 1.1 per cent, and that therefore the data of the two series of tests are in fairly good agreement.

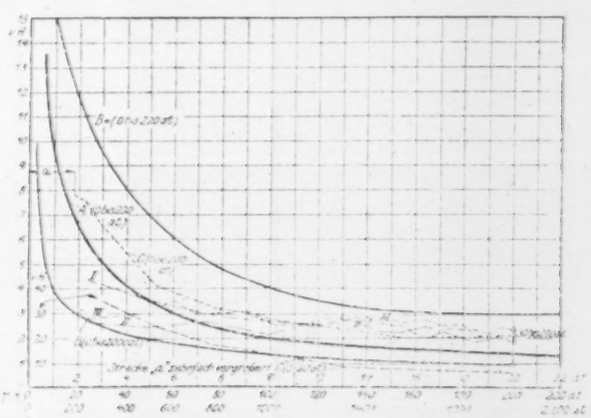

FIG. 15 CURVES OF CUP-LEATHER FRICTION

(Curve *A*, Martens; curve *B*, Puppe; curves I, II, III, author's tests on 300-ton concrete press; curve *C*, author's tests on 75-ton bending machine. (*Bis* = to; *at.* = atmospheres; *vH* = per cent; *Strecke "a" zehnfach vergroessert* = section "a" magnified ten times.))

On the other hand, however, in nearly all cases the sleeve-friction values as obtained by the present author were higher than those obtained in the Martens test, which may be due to the fact that the pressure fluid in the present instance was not entirely free from dust and fine grains of sand, which is also the usual condition in actual operation. It was also found that the first measurements carried on after a period of several hours of rest of the measurement always gave slightly higher friction values than later tests. This was particularly so in early morning tests which followed the idle period of 10 to 15 hr. when the leather cup had a chance to become dry. After the piston has moved up and down for some time the

values come back to within 0.5 to 1.1 per cent of the Martens values. The friction values obtained by Dr. Eng. Puppe in 1910 are given in curve *B* for the sake of comparison. Furthermore, the present author has carried out several comparative tests during the war on a 300-ton concrete press. The data of these tests are given in curves I, II and III, Fig. 15. All these curves agree fairly well with each other, though the high frictional values of Dr. Puppe would indicate that at high pressures rubber packing rings produce a considerably higher friction than leather cups.

In Fig. 16 is graphically indicated the relation between the load *P* and the friction R_p. From the appearance of the curve of friction it would seem that at a pressure of 10 tons, or roughly 25 atmos., the pressure amounts to only 6.6 per cent, while at 75 tons, or, say, 200 atmos., it is only 2.1 per cent.

The division of the pressure-gage dial into kilograms appears to be a material improvement in testing machines. In the majority of cases one may allow an error of ± 2.5 per cent, although a greater precision can be obtained by the use of a control manometer.

Table 3 gives the cup-leather friction in percentages of *Fp* and

TABLE 1 COEFFICIENTS OF FRICTION (MARTENS)

(1) *P* tons = 2200 lb.	(2) *p* Atmospheres	(3) Per cent	(4) Atmospheres	(5) Atmospheres
1	2.63	....	....	.....
2	5.27	....	....	.....
3	7.9	....	....	.....
4	10.54	....	....	.....
5	13.17	....	....	.....
6	15.8	....	....	.....
7	18.43	....	....	.....
8	21.1	....	....	.....
9	23.7	....	....	.....
10	26.3	5.6	1.48	27.78
15	39.5	4.3	1.70	41.2
20	52.7	3.4	1.79	54.49
25	65.8	2.8	1.84	67.64
30	79.0	2.5	1.98	80.94
35	92.3	2.2	2.03	94.33
40	105.4	2.0	2.1	107.5
45	118.5	1.9	2.25	120.75
50	131.7	1.8	2.37	134.07
55	145	1.75	2.54	147.54
60	158	1.65	2.61	160.61
65	171	1.60	2.74	173.74
70	184.3	1.55	2.86	187.16
75	197.1	1.55	3.06	200.16

TABLE 2 DIFFERENCES BETWEEN THE FRICTION VALUES AS FOUND BY MARTENS AND AS INDICATED BY GAGE, IN PER CENT

	Atmospheres								No. load
	10	20	30	40	50	60	70	75	
1	1.05	0.45	0.85	0.75	0.27	0.48	0.11	0.40	0.55
2	0.9	0.83	0.33	0.40	0.43	0.48	0.33	0.29	0.33
3	1.1	1.00	0.85	0.75	0.40	0.46	0.39	0.25	0.56
4	0.9	0.90	0.85	0.34	0.94	0.66	0.87	0.66	0.76
5	1.1	0.98	0.63	0.68	0.95	0.71	0.74	0.58	0.48
6	0.99	0.80	0.76	0.65	0.79	0.35	0.91	0.58	0.63
7	0.75	0.95	0.68	0.79	0.82	0.88	0.61	0.66	0.59
8	1.13	0.30	0.55	0.83	0.64	0.73	0.84	0.52	0.48
9	0.88	0.86	0.76	0.53	0.66	0.53	0.69	0.63	0.59
10	0.76	0.90	0.82	0.70	0.49	0.67	0.47	0.82	0.75
Average	0.96	0.80	0.71	0.64	0.64	0.59	0.60	0.54	....

TABLE 3 SLEEVE FRICTION IN PER CENT OF F_p AND f_p AS FOUND EXPERIMENTALLY BY AUTHOR

$P = pF$ tons	*p* Atmospheres	*fp* kg.	Friction in Per cent of F_p	Friction in Per cent of f_p
1	2.63	920	37	40.3
2	5.27	1845	25	27.2
3	7.9	2770	17	18.5
4	10.64	3500	12.5	13.6
5	13.17	4600	9.3	10.1
6	15.8	5530	8.9	9.65
7	18.43	6450	8.4	9.1
8	21.1	7400	7.6	8.25
9	23.7	8300	7	7.6
10	26.3	9200	6.56	7.13
15	39.5	13800	5.45	5.93
20	52.7	18450	4.20	4.55
25	65.8	23050	3.75	4.07
30	79.0	27700	3.21	3.49
35	92.3	32350	3.00	3.26
40	105.4	35000	2.64	2.87
45	118.5	41500	2.55	2.77
50	131.7	46000	2.44	2.65
55	145	50700	2.35	2.55
60	158	55300	2.24	2.44
65	171	59800	2.20	2.40
70	184.3	64500	2.15	2.34
75	197.1	69000	2.10	2.28

$f\,p$, where $f = 350$ sq. cm. is the sum of all surfaces of the cup leathers in friction. The values in the last column are also of interest as they give the coefficients of friction of cast iron against leather at various pressures per unit of area. [Note: 1 sq. cm. = 0.1550 sq. in.; 1 kg. per sq. cm. = 14.223 lb. per sq. in.; 1 metric ton = 1000 kg. = 2200 lb.] (*Zeitschrift des Vereines deutscher Ingenieure*, vol. 65, no. 39, Sept. 24, 1921, pp. 1016–1017, 2 figs., *eA*)

VARIA

Agitation for Changes in Canadian Patent Law. John Munnock, Division Court Clerk of the Sault Ste. Marie District, in speaking before the Board of Trade of that town, advocated important changes in the practice of the Canadian Patent Act.

Under the law Americans obtaining patents in Canada are required to begin manufacture in Canada within two years, but may obtain an extension for one more year. It is claimed that this provision of the Act is not enforced and that there are 10,000 articles that could have been manufactured in Canada but are instead imported from America.

It is also claimed that even if an American patentee failed to meet the requirements of the Act as regards manufacture in Canada, he can still obtain an injunction against a Canadian manufacturer infringing his patent.

To meet this situation, the speaker proposes a closer check on the

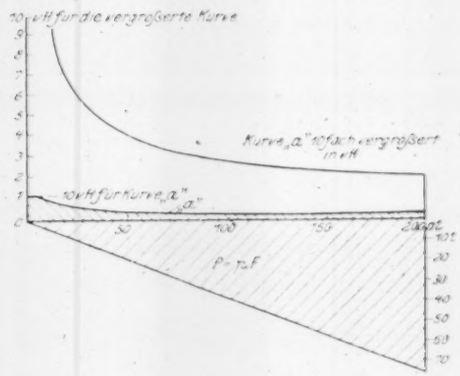

Fig. 16 Relation Between Load *P* and Friction R_p for Loads from Zero to 200 Atmos.

(*vH für die vergroesserte Kurve* = per cent for the magnified curve; *Kurve "a" 10fach vergroessert in vH* = curve "a" magnified ten times in per cent.)

compliance of foreign patentees with the requirements of Canadian laws, and it is claimed that he has carried the matter to Premier Meighen, who is said to have expressed regret that action could not have been taken by the government prior to election.

The subject was expected to come up for discussion at the Brantford Convention of the Canadian Associated Boards of Trade in November, 1921. This matter affects a large number of American products, among others being American typewriters, cash registers, adding machines, check protectors and machine tools. (*Canadian Machinery and Manufacturing News*, vol. 26, no. 21, Nov. 24, 1921, p. 52, *g*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

Starting Aero Engines at low Temperatures. (Air Board, Ottawa, Canada, Technical Memo No. 15.) From preliminary reports of Experiments carried out last winter by Professor Robb, at Edmonton, it is suggested that the following means of starting Liberty engines at low temperatures may be found to be effective. A complete report will be circulated as soon as received. It is suggested that for the efficient doping of the engines some form of priming pump similar to the Rolls-Royce primer is necessary. At temperatures over 20 deg. fahr., liberal doping with gasoline is sufficient except that the motor will require to be turned over several times after doping to case it up. At temperatures between 20 deg. fahr. and ten deg. fahr. doping with a mixture of three parts gasoline to one part of ether will be found to be effective. At temperatures around zero, a one to one mixture is satisfactory. At temperatures in the neighborhood of 12 deg. below zero, it will be found that a mixture of two parts ether to one part gasoline is required.

ENGINEERING RESEARCH

A Department Conducted by the Research Committee of the A.S.M.E.

Research Résumé of the Month

A—Research Results

The purpose of this section of Engineering Research is to give the origin of research information which has been completed, to give a resume of research results with formulas or curves where such may be readily given, and to report results of non-extensive researches which in the opinion of the investigators do not warrant a paper.

Apparatus and Instruments A1-22. Scales. Technologic Paper 199 of the Bureau of Standards outlines scientific and systematic procedure for accurate testing of large-capacity compound lever scales by a method developed by the Bureau. Apparatus is described and method of testing is explained. Paper may be obtained at a cost of 5 cents from the Superintendent of Documents, Washington, D. C.

Cement and Other Building Materials A1-22. Bricks. Sand-Lime and Other Concrete Bricks is the subject of Special Report No. 1 of the Building Research Board of Great Britain. The report is divided into two sections, one on sand-lime bricks, the other on cement-concrete bricks. Each section treats of materials, costs, quality, uses and manufacture. It may be obtained at 4d from Imperial House, Kingsway, London, W. C. 2.

Friction and Allied Subjects A1-22. Ball and Roller Bearings. Technologic Paper 201 of the Bureau of Standards describes the tests and gives the conclusions of tests performed on ball bearings and flexible roller bearings under various loads with balls and rollers of different sizes and different hardness with varying radii of races. This report is of great value to any one interested in design of ball and roller bearings. This may be obtained at 10 cents per copy from the Superintendent of Documents, Washington, D. C.

Fuels, Gas, Tar and Coke A1-22. The Coking of Utah Coals. The Coking of Utah Coals is the subject of Report 2278 by Prof. S. W. Parr and T. E. Layng to the Bureau of Mines. Approximate and ultimate analyses were made. The oxygen content was very high. The oxygen-hydrogen ratio was also very high. This indicates a non-coking property. The preliminary tests seem to indicate this but this feature was overcome and a good quality of coke obtained accompanied by a series of by-products of more than usual interest and value. The ammonium sulphate produced was exceedingly constant and averaged 20 lb. per ton. Large-scale operations would probably increase this. The gas yield was low, being 3½ cu. ft. per lb. of coal. The production of gas was very uniform. The heating value of the gas was large. The tar yield averaged 25 to 30 gal. per ton. The coke yield amounted to approximately 60 per cent of the coal employed. It was dense, of good texture and adapted to the usual screen and sizing process. It would probably be suitable for metallurgical purposes. There is considerable volatile matter present in the coke varying from 8 to 12 per cent. The temperature used to carbonize the Utah coals did not exceed 750 or 800 deg. cent. Bureau of Mines, Washington, D. C. Address H. Foster Bain, Director.

Fuels, Gas, Tar and Coke A2-22. Natural Gas-Gasoline Blends. Report 2279 of the Bureau of Mines on Natural Gas-Gasoline Blends, by D. B. Dow, was issued last September. Natural gas-gasoline is obtained by compression and collecting of natural gas. The gasoline dissolves a certain amount of volatile material which evaporates rapidly at atmospheric temperature and pressure. With lean natural gas the gas vapors are absorbed by absorbing oil, after which it is distilled from the saturated oil. This gasoline is of higher gravity and lower vapor pressure than the compression gasoline. To transport the volatile gasoline it must be blended with suitable material such as naphtha or weathered, in which case the volatile portion is allowed to evaporate causing loss. It is difficult to produce blended gasoline which is equal to refinery gasoline. Hence only a small amount of gas-gasoline can be blended with naphtha. Blends are sometimes made with kerosene and subsequently distilled, the kerosene acting as a carrying agent. Most common material is of naphtha range from 50 to 52 Baumé. Bureau of Mines, Washington, D. C. Address H. Foster Bain, Director.

Fuels, Gas, Tar and Coke A3-22. Recovery of Unburned Fuel from Boiler Furnace Refuse. Report 2281 of the Bureau of Mines on the Recovery of Unburned Fuel from Boiler Furnace Refuse, by Thomas Fraser and H. F. Yancy, has just been issued. The report shows that washing may be used to recover a large portion of the unburned fuel. The results of the test showed that with ³/₈-in. screening and ¹/₄-in. oversize 20 per cent of the refuse was regained as washed fuel. A one-table plant will handle five tons of boiler refuse per hour, producing one ton of fuel. The equipment for such a plant would consist of a roll crusher, a storage hopper, a screw conveyor, washing table and two inclined dewatering drag conveyors. If water is scarce or costly, overflow from sumps may be clarified and returned to the system. The operation would require the part time of one man. Bureau of Mines, Washington, D. C. Address H. Foster Bain, Director.

Heat A1-22. Heat-Transfer Coefficient. The heat transfer between hot and cold oil in double-pipe heat interchanger used in distilling gasoline shows an average value of 20.05 B.t.u. per hour per degree per sq. ft. In most cases the mean temperature difference computed by the log formula was about 70. The efficiency of heat transfer in apparatus averaged 78 per cent on account of radiation. Information is from reliable source but name is withheld.

Petroleum, Asphalt and Wood Products A1-22. Viscosity of Petroleum Oils. The following notes are obtained from the thesis of Mr. Achille R. Albouze on the Logarithmic Relation between Temperature and Pressure of Petroleum Oils:

The logarithms of temperature and absolute viscosities of the oils were plotted and there was found to be a close adherence to a straight-line law from ordinary room temperature of 70 deg. fahr. to temperatures of 180 to 220 deg. fahr., depending upon the nature of the oils. Around this region of temperatures (180 to 220 deg.) there appears to be a "break" in the straight-line law, but after passing this critical point the oils then invariably follow another straight-line law up to 300 deg. fahr., but at a lesser rate of change of viscosity than at the lower temperatures. In other words, the absolute viscosities of the oils may be represented as two intersecting straight lines as far as 300 deg. fahr.

This critical point where the lines seem to break off is fairly uniform, as was evidenced on plotting gravities, absolute viscosities at 100 deg. fahr. and temperatures at which the breaks in the straight lines occurred. A study of these curves shows:

1 That the greater the density and absolute viscosity of an oil, the higher is the temperature at which the break occurs.

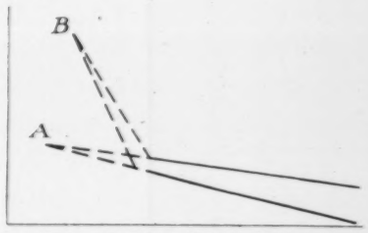

Fig. 1

2 The lines showing relations between viscosity and the "critical breaking temperatures" parallel themselves to a degree of remarkable closeness.

3 Oils of specific gravity below 0.9 show higher "breaking point temperatures" than oils of specific gravity greater than 0.9.

The oils purchased as "paraffin base" oils showed specific gravities at 60 deg. fahr. or less than 0.91 and their rate of change or loss of viscosity per degree of temperature rise was less than the so-called "asphalt and napthene" base oils. Comparing the "paraffin" base with the "napthene" base oils of similar absolute viscosity, it appears that the breaking-point temperature of the "paraffin" oils is generally from 15–20 deg. fahr. higher than the "napthene" base oils. The following table based upon the experimental data obtained in this laboratory (Mechanical Engineering Laboratory, Stanford University) serves to show these points more clearly.

Base of Oil	Sp. Gr. at 60 deg. fahr.	Abs. Visc. at 100 deg. fahr. (poises)	Temperature, deg. fahr., at which lower straight lines break
Napthene	0.92–0.94	0.25–0.75	180–195
Napthene	0.93–0.95	0.75–1.25	190–205
Napthene	0.94–0.95	1.25–2	205–215
Napthene	0.94–0.95	2–4	210–215
Paraffin	0.875–0.90	0.25–0.75	200–220
Paraffin	0.875–0.90	0.75–1.50	210–230
Paraffin	0.875–0.90	1.50–2.25	220–250

An examination of the lines on the logarithmic sheets indicate that the oils tend to converge toward a common point, this being particularly true of oils (or products of oils similarly treated) from the same fields. None of the oils tested showed a continuous straight line from room temperature to 300 deg. fahr., but all can be represented by two straight lines intersecting one another around the region of 200 deg. fahr., as shown in Fig. 1.

If the lines for the lower range of temperatures are prolonged it will be found that they tend to meet at a common point *A* of the diagram. In a similar manner the upper lines through viscosity determinations

from 200 to 300 deg. fahr. indicate a convergency also, but the point of intersection *B* appears to lie at a still further distance away from the point of convergency for the lower temperatures.

No further statements regarding the common points of intersection can be given here, other than to briefly indicate that there are evidences of there being such points, principally because a lack of time has made it impossible to study this particular case thoroughly.

The establishment of the existence of a common point of convergence would be of great practical importance. By this means it would be possible to know the absolute viscosity of any mineral lubricating oil (at any temperature) after one or two viscosity measurements had been made. If the absolute viscosity followed but one straight line over the entire range of temperatures instead of two, it would only be necessary to know the viscosity of an oil at any one temperature—the absolute viscosity of the oil being given by the line connecting the common point of convergence and the viscosity as found by measurement.

Viscosity and density measurements made at lower temperatures after the runs at 300 deg. fahr. had been obtained indicate that the oil underwent no appreciable changes. Most samples showed only a slight increase in viscosity and density due to evaporation. Experiments seemed to show that there were no measurable differences in viscosities regardless whether the values were obtained with increasing or decreasing temperature.

The two Mexican crude oils show also a characteristic straight line law from 150 to 300 deg. fahr. with only a slight tendency to indicate that they are made up of two broken lines. On cooling both samples showed increased viscosities due to the loss of low boiling point components.

Mr. Albouze's thesis includes in addition to the data and results of his own tests, a summary of which is given above, a study of all of the published data on viscosity of oils from various authorities and determined with various types of viscosimeters; a bibliography of physical and chemical tests for internal engine lubricating oils and a section devoted to notes and critical review of bibliography. The bibliography covers 188 publications. Address Prof. W. R. Eckart, Leland Stanford University, Stanford, Cal.

Rubber and Allied Substances A1-22. Tests of Rubber Goods. Circular 38 of the Bureau of Standards has just been issued. The subject of the circular is the test of rubber goods giving the physical and chemical methods used at the Bureau with an introductory portion giving information concerning crude rubber and manufacture of rubber goods. Materials used in compounding rubber are classified and process of manufacture described, with brief summary of the detail of manufacture of tires, tubes, mechanical goods, druggists' sundries, methods of physical tests with data of results as well as methods of chemical analysis are given. Methods of testing fabrics are included. The Appendix contains a list of governmental specifications, a bibliography of papers published by the Bureau and of the more important books and periodicals that deal with rubber. A table of specific gravities of the common compounding ingredients is given. Circular may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C. for 20 cents.

Safety Devices A1-22. Head and Eye Safety Code. A second edition of the Head and Eye Safety Code is soon to be published by the Bureau of Standards. This will include specifications for goggles, welding helmets and other protectors. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Steam Power A3-21. Steam Action in Simple Nozzle Forms is the subject of a paper read by A. L. Mellanby and William Kerr before the British Association in August, 1921. A paper on Pressure Flow Experiments on Steam Nozzles was read before the Institute of Engineers and Shipbuilders in Scotland November, 1920, while in February, 1921, a paper on the Losses in Convergent Nozzles was published. This paper was read before the Northeast Coast Institute of Engineers and Shipbuilders. The various papers give pictures of apparatus used, curves showing observed data and theoretical curves discussing the action of steam jets in nozzles. These sets of papers contribute largely to our present knowledge of steam flow.

B—Research in Progress

The purpose of this section of Engineering Research is to bring together those who are working on the same problem for cooperation or conference, to prevent unnecessary duplication of work and to inform the profession of the investigators who are engaged upon research problems. The addresses of these investigators are given for the purpose of correspondence.

Apparatus and Instruments B1-22. Acidity and Alkalinity Recorder. An instrument for determining the alkalinity or acidity of boiler feed to automatically control additions of caustic soda to eliminate acid conditions. The principle used is that of measurement of concentration of the hydrogen ions. A hydrogen electrode and calomel electrode are immersed in a by-passed flow of feedwater from the heater tanks. The potential difference measured depends on the H-ion concentration. Results of data so far indicate that method would prove satisfactory. Address E. A. Keeler, Leeds & Northrup, Philadelphia, Pa.

Automotive Vehicles and Equipment B1-22. Experimental Tunnel for Studying Exhaust Gas. See *Internal-Combustion Motors B11-21.*

Boilers and Accessories B1-22. Acidity and Alkalinity Recorder. See *Apparatus and Instruments B1-21.*

Internal-Combustion Motors B1-22. Experimental Tunnel for Studying Exhaust Gas. Report 2288 of the Bureau of Mines on the Bureau of Mines Experimental Tunnel for Studying the Removal of Exhaust Gas, by A. C. Fieldner and J. W. Paul, gives an account of the purposes of the investigation and results found as reported under *Automotive Vehicles and Equipment A5-21*, in Mechanical Engineering for June, 1921. The report gives the following particulars of the construction of this experimental tunnel.

An oval track having an axial length of 400 ft. and having similar construction to that of the ducts proposed in the Hudson River Tunnel, was constructed under ground with a cross-section approximately 9 ft. wide and 8 ft. high. Above the tunnel is an air duct 3 ft. high and below the floor another air duct 3½ ft. high. Either duct may be used for introducing fresh air or for exhausting contaminated air. The tunnel accomodates the smaller types of five-passenger cars. It is completely equipped with sensitive apparatus for measuring temperature, humidity, air pressure and air velocity. Forty-eight air-sampling tubes are installed at eight cross-sections of the tunnel to obtain samples for chemical analysis and to determine diffusion and concentration of exhaust gases. The experimental tunnel tests will include physiological and psychological observations of the effects on the man driving the cars, of temperature, humidity, rate of air flow, smoke and exhaust gases. Ten cars at 40-ft. intervals will be run at the rate of 10 miles per hour and 21,000 cu. ft. of air per minute will be introduced so as to keep the carbon monoxide at 4 parts per 10,000 parts of air. Each driver and observer will be subjected to examination before and after the tests. The tunnel is situated 130 ft. below the surface of the ground and 150 ft. from the pit mouth. The study will include the diffusion of exhaust gases by transverse ventilation, bottom to top and top to bottom, temperature and smoke conditions as effected by operation of motor cars, physiological and psychological effects of temperature, exhaust gases and smoke, final check of previous investigation and practical demonstration of solution of problem.

Bureau of Mines, Washington, D. C. Address H. Foster Bain, Director.

Metallurgy and Metallography B1-22. Deoxidizers. Progress Report to the Division of Engineering of the National Research Council on Substitute Deoxidizers gives some of the work which has been done by the Committee on this subject. The Committee has standardized its work and is now treating standard metal with various deoxidizers in an atmosphere of nitrogen within an induction furnace. The standard metal is commercially pure American ingot iron and iron oxides melted together in an electric furnace in such proportions that the iron thus made give 0.5 to 0.6 per cent oxygen. When this standard metal is melted the deoxidizer is added and allowed to act for 5 or 10 minutes with the heat on the furnace. The melt is then allowed to solidify or is poured into a chill mold. The ingot is then split, examined and photographed. One-half is then forged and the forging properties noted. The forged ingot is then examined microscopically for inclusions and chemically for oxygen and residual amounts of deoxidizing elements.

This work has been repeated in some cases in a 40-lb. experimental electric furnace of the American Rolling Mills Company. Each deoxidizer is to be added in different amounts to determine the proper amount to be used. Certain of the deoxidizers have proven of special value in preventing segregation. Others indicate inability to replace manganese in eliminating sulphur red shortness. Some have shown a refining influence on grain structure and others have shown the possibility of reducing ingot loss from discards due to shrinkage cavities. In the earlier work the Committee has found 73 combinations of elements which promise to be of value as deoxidizers. All contain manganese, but many of them contain less than 2 per cent of this element. As the first steps of deoxidation could be effected by these alloys and the final deoxidization with high-percentage ferromanganese, a great saving can be accomplished.

The functions of the deoxidizer are:

1 To produce the greatest possible yield of sound ingots free from blow holes and with a minimum amount of shrinkage cavities

2 To produce steel possessing satisfactory rolling and forging properties

3 To produce metal free from iron oxide, slag or other solid inclusion, and

4 To produce steel with maximum freedom from dissolved gases.

The report is made by Dr. J. R. Cain, Chairman, Committee on Substitute Deoxidizers. Address Division of Engineering, National Research Council, 29 West 39th St., New York City.

Properties of Engineering Materials B1-22. Corrosion of Pipes. The Bureau of Standards is beginning an investigation of the corrosive action of soil upon iron pipe. Investigations are being made with the coöperation of the Bureau of Soils, Pipe Manufacturers, Public Utility Companies and the Bureau of Standards. Forty locations have been selected representing different kinds of soil found through the United States, and in each locality a number of samples of each kind of iron and steel pipe in commercial use will be buried. One of these pipes will be uncovered from time to time to determine the rate of corrosion. Complete data of the physical and chemical properties of soil and pipes will be obtained. Extensive laboratory experiments will be conducted to determine the effects of variations and characteristics of both soil and pipe materials. Tests will also be made of representative pipe coverings. The investigation will probably take eight to ten years. The progress report will be published from time to time. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

Protective Devices B1-22. CORROSION OF PIPES. See *Properties of Engineering Materials B4-21.*

Safety Devices B1-22. SAFETY CODE FOR LOGGING OPERATIONS. A National Safety Code for Logging and Saw Mill Operations is being prepared by the Bureau of Standards with the assistance of a Sectional Committee. This Code is nearing completion. Bureau of Standards, Washington, D. C. Address S. W. Stratton, Director.

C—RESEARCH PROBLEMS

The purpose of this section of Engineering Research is to bring together persons who desire cooperation in research work or to bring together those who have problems and no equipment with those who are equipped to carry on research. It is hoped that those desiring cooperation or aid will state problems for publication in this section.

D—RESEARCH EQUIPMENT

The purpose of this section of Engineering Research is to give in concise form notes regarding the equipment of laboratories for mutual information and for the purpose of informing the profession of the equipment in various laboratories so that persons desiring special investigations may know where such work may be done.

E—RESEARCH PERSONNEL

The purpose of this section of Engineering Research is to give notes of a personal nature regarding the personnel of various laboratories, methods of procedure for commercial work or notes regarding the conduct of various laboratories.

F—BIBLIOGRAPHIES

The purpose of this section of Engineering Research is to inform the profession of bibliographies which have been prepared. In general this work is done at the expense of the Society. Extensive bibliographies require the approval of the Research Committee. All bibliographies are loaned for a period of one month only. Additional copies are available, however, for periods of two weeks to members of the A.S.M.E. These bibliographies are on file at the office of the Society.

Machine Tools F1-22. TORQUE AND POWER REQUIRED FOR TAPPING AND THREADING. A bibliography of three items. Search No. 3469. Address A. M. Greene, Jr., Rensselaer Polytechnic Institute, Troy, N. Y.

WORK OF THE A.S.M.E. BOILER CODE COMMITTEE

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and simultaneously published in MECHANICAL ENGINEERING.

Below are given the interpretations of the Committee in Cases Nos. 370 to 374 inclusive, as formulated at the meeting of October 27, 1921, and approved by the Council. In accordance with the Committee's customary practice, the names of inquirers have been omitted.

CASE NO. 370

Inquiry: Is it permissible, under the rules in the Boiler Code, to construct a boiler drum, 36 in. internal diameter, built with the shell in one sheet, $^{13}/_{16}$ in. thick, with one longitudinal seam having butt straps $^{1}/_{2}$ in. thick on each side? Information is also requested as to the maximum allowable working pressure as determined by the efficiency of the longitudinal seam and the tube-hole ligament.

Reply: It is the opinion of the Committee that a boiler drum constructed as described does not conform to the requirements of Par. 19 of the Code. The Committee is not in a position to determine the maximum allowable working pressure for constructions not permitted by the Code and would recommend that the question be taken up with the state authorities or insurance companies interested.

CASE NO. 371

Inquiry: Is it permissible to construct vertical fire-tube boilers of either the through-tube or submerged-tube types with the tubes welded in both the upper and lower tube sheets?

Reply: It is the opinion of the Committee that Par. 250 was not intended to forbid rolling and welding at both ends of the tubes of a fire-tube boiler, when desired.

CASE NO. 372

Inquiry: An opinion is requested as to the actual distance above tubes at which the fusible plug should be inserted in economic-type boilers under the requirement of Par. 430*r*. Is 1 in. above the upper row of tubes sufficient?

Reply: It is the opinion of the Committee that, as this type of boiler is quite similar in construction to an h.r.t. boiler, an elevation of the fusible plug 2 in. above the upper row of tubes will be necessary to meet the requirements of Par. 430*r*.

CASE NO. 373

Inquiry: Will the rules in the Boiler Code for calculation of the Adamson type of furnace apply to the design of conical furnace shown in Fig. 20, using the mean diameter of the cone as the nominal diameter of the furnace, and is it permissible in such construction to form the two vertical seams therein by autogenous welding?

Reply: It is the opinion of the Committee that Par. 231 covers the construction described. Autogenous welding is not permissible in this type of boiler, except in those portions of the furnace which are to be stayed.

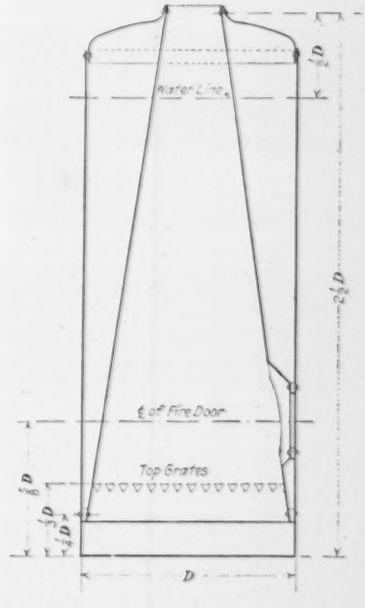

FIG. 20 DESIGN OF VERTICAL BOILER WITH CONTINUOUS UNSTAYED CONICAL FURNACE

CASE NO. 374

Inquiry: Does the requirement of Par. 256 of the Code, relative to the term: "machine driven," refer solely to hydraulic or other forms of pressure riveters, or will pneumatic riveters conform to this requirement?

Reply: It was the intent of the Committee that the term: "machine driven" should apply only to those types of riveting machines which are able to drive the rivets with sufficient pressure to fill the rivet holes and allow them to cool and shrink under pressure.

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers and Proceedings of

The American Society of Mechanical Engineers

29 West 39th Street, New York

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C 55 The Society as a body is not responsible for the statements of facts or opinions advanced in papers or discussions.

Methods and Results of the Unemployment Conference

THE management of The Unemployment Conference called in Washington September 26, was clearly enough in the hands of a man of scientific training and practical experience, whose mind would not rest content with the convenient superstition that if a considerable number of men and women are called together and allowed to simmer, something first-rate must happen somehow. He knew that merely jumbling together some sulphur and charcoal and ammonia water never made aniline dye, not even if you stirred them with a stick—that the mere presence of the elements of a successful conference would not guarantee success. Its possibilities and impossibilities he assayed in advance, and planned and managed the job with the cool scientific purpose of getting for the country the maximum practical results. Best of all there was no belief that by some magic a lasting socio-economic influence could take form from a few weeks of conference, no matter how well managed. Hence, the several projects which the conference started are being persistently followed up by individuals or small committees under the leadership of the Department of Commerce.

HENRY S. DENNISON

The Conference had two principal fields of work, the curative and the preventive. It had to accept the fact that we were in an economic mess and propose measures by which we might tide ourselves over or pull ourselves out of the emergency; and it had to search out every kind of influence which might help in keeping us from getting quite so deep into the same kind of mess again.

Emergency measures were studied first, and preliminary findings were made with remarkable speed. Through its command of the counsel of men of prior experience and by promptly dividing its work among relatively small committees, the conference was able within a very short time to formulate a close approach to standard practice in the work of employment bureaus and relief agencies, which most communities are undertaking this winter. By placing the responsibility for the institution of such work upon the mayors, a perfectly specific record of accomplishment and follow-up was made possible; and the conference was no sooner over than Colonel Woods devoted his whole time to this service. Where jobs are scarce and we run into the second winter of unemployment, intelligent forehanded placement and relief will in no inconsiderable number of cities make all the difference between order and lawlessness.

While the results of the Conference in providing more jobs than would otherwise have been available must have been small, here again its greater effectiveness lay in an intimate follow-up of the public announcements. Members of the Conference and notably one president of a large employers' organization, backed up the spirit of the Conference by taking up very definitely with individual concerns the necessities of doing as much repair work, advance construction and making-to-stock as good business principles would allow, and the advantages of distributing the burden of idleness among their employees by rotation of jobs and part-time work. The same definite sort of follow-up resulted in the clearance of hundreds of State and Federal projects already acknowledged to be worth undertaking but hung up for some reason or other.

The very sense of inadequacy which any thorough exploration of the field of emergency work must arouse was a good preparation for the members of the Conference in undertaking the tasks of more permanent importance. So far the business world as a whole has seemed content to accept constantly recurring periods of inaction following periods of scarcely less expensive feverishness as visitations of any angry economic Jehovah. As yet only the pioneer bits of research into the complex of causes of the business cycle have been completed. As a result of the Conference there will be carried on during the next six months an investigation of causes more expert and extensive than has ever before been attempted. If it fails to discover our economic rats and fleas, or our commercial anopheles, at least it will come near enough to it to excite a scientific curiosity which will not be allayed.

It is not an unreasonable supposition that the exaggerations of prosperity and depression which are the source of our greatest damage might be laid largely to the present necessity of business concerns going it blind, without some of the data essential for their continuous guidance. In making definite recognition of this the Conference gave a fresh spur to the projects of the Department of Commerce and a fresh inspiration to the various trade associations to give us pertinent and prompt statistics.

In the field of government, fruit of the conference is already apparent in the Bill (Senate 2749) offered by Senator Kenyon to encourage and provide for reservation of a part of the public works determined upon and appropriated for during prosperous times to furnish worth-while work during times of depression. This will withdraw some government projects from competition in a crowded and high-priced market, to the advantage of the business and laboring community and of the government as well.

Besides the unemployment due to cycles the Conference paid attention to seasonal unemployment, and in the same spirit refused to bow to the God of Things As They Always Were. For the diagnosis of this continuous industrial sickness the managers of the conference recognized that each industry offers a problem of its own, so provided special committees to make the long study of possibilities in building trades and mining industries which is necessary before any significant suggestions for improvement can be hoped for.

In addition to all these projects the Conference undertook to put through to a point of real accomplishment a consideration of the relation of unemployment to the railroad problem, to foreign trade, and to shipping, and a statistical resurvey of the extent of unemployment. One has only to appreciate the variety of temperaments and trainings which had to be gathered together in the men and women who had done enough thinking on this formidable list of projects to have definite and individual points of view, to realize that such a group of folk plunged into open meetings would have met certain failure. Points like this were thought out in advance. The Conference therefore, was divided immediately into committees of workable size, each of which got down to the special problems prepared for it in preliminary form by an Advisory Committee appointed three weeks before the

Conference met, and began to grind itself into bearing with greater or less speed, depending upon the skill of its chairman. But this method would have lost a public interest of very great value by lack of news material, so public hearings were held beginning the second day, at which the problems of each committee were taken up in turn. When the conference as a whole was ready to meet there had already been accomplished by these methods so much adjustment of points of view and so much broadening of the understandings of the precise nature of their problems that it was easily possible to find ground for unanimous declarations of the general principles governing the various phases of the problem.

There were still left very fundamental differences of opinion as to the applications of these principles, as it was foreseen that there must be in any such gathering. By the traditional method of letting such Conferences run, these fundamental differences, being largely temperamental or environmental, and thus non-judiciable, would have materialized into long speeches seasoned with some bitterness; and then the magical ceremonies of nose-counting would have been invoked. Now the Conference was clearly not a legislative body. Mr. Hoover had coolly estimated what it was and was for and in what ways it could serve the country. He knew that people might well be influenced by the unanimous opinions of such a group of thoughtful people, but that on any question upon which members of the conference differed, the public would first want to know who believed thus and who so. Therefore such measures as the committees failed to agree upon were presented to the country through reports signed by those whose views they represented; and matters that had been so threshed out as to constitute a final coördination of the wide range of experience represented at the Conference, were given form as unanimous declarations.

This sounds simple enough in the telling; but actually the whole procedure was a case of thoughtful and ingenious development of the technique of such conferences which, so far as I know, sets a new standard. With such an example behind us there is no more need for our making the mistakes we have made in the past in such matters than there would be for a railroad constuction engineer now to lay out curves sharper than his locomotive trucks could negotiate.

The engineering profession can find much of interest in the final accomplishments of the conference, especially when the standing committees complete their assays of the serious conditions in great seasonal activities like building and mining; but the profession cannot afford to be less interested in the example of sound social engineering which the method of management of this Conference affords. Our social structure has grown in complexity well beyond the abilities of any one or two men to chart its proper courses. We shall need more of such conferences. And it is well that an engineer has come to judgment, that they may be managed with an appreciation of the real forces and opportunities involved in them.

HENRY S. DENNISON.[1]

The Unique Opportunity of the Railroad Professional Division

EVERY individual in the land is dependent upon the power that pulls trains. In fact, the progress of the nation and the progress of transportation are inseparable. Our Society offers means for record and for discussion of developments in the application of power and equipment for transportation. This places before the Railroad Professional Division of this Society a remarkable opportunity.

Inspirations are coming from all directions, from railroad officers, from engineers connected with the builders of railway equipment, and from engineers who are in the service of companies not directly connected with the railroads or with the builders of cars or locomotives.

Wonderful results have already been obtained and even greater results are in sight, having in mind the development of electric power for transportation, steam power and equipment to carry loads, both passenger and freight. Problems are repeatedly coming up for discussion, the solution of which with the highest of efficiency will depend very largely upon the getting together of all the engineers who are devoting their lives to this progress. Our Society offers the only forum for these studies and discussions which are so important to us all.

Electric-locomotive and steam-power developments are coming on apace. Electric applications are progressing and improvements are being made. Steam locomotives have been improved and the present generation of engineers has brought to the steam locomotive improvements which were not dreamed of fifteen years ago, and the possibilities of which are not yet apparent to even railroad officials at the present time. Improvements now under development promise even greater efficiency in the steam locomotive than has ever yet been obtained.

Electricity and direct steam for railroad transportation are in competition. It is most important that those who are devoting their attention to the development of the steam locomotive should thoroughly understand what electricity is doing. On the other hand, it is equally important that electrical engineers should know that the steam locomotive of today offers possibilities that are far beyond those of the steam locomotive of ten or more years ago, and that the railroads have before them more improvements in their steam power than they have ever used. In other words, the steam locomotive as we know it right now is very different from the one we knew a few years ago.

Moreover, in a few years, if full advantage is taken of the possibilities of increasing the power per pound of weight and the power produced by a pound of coal, the steam-locomotive figures which we are now talking about will of necessity be changed. This Society offers the means for bringing out the best and latest facts regarding these developments, and of bringing together the men who know these problems. It provides the means for using to advantage the mature thought of the best engineers of this country, which of all countries is most indebted to transportation and which depends most upon transportation for its future. No other organization of engineers provides such means for getting these authorities together for mutual understanding.

G. M. BASFORD.

The Relation of the Engineer to the Community[1]

AS GOVERNOR, the elected head of a state government, there are two angles of this question to which for a few minutes, I might call your attention. One is the practical side, simply a list of those positions in our state government which must be filled by competent engineers. Upon this I shall only dwell for a moment.

Bachrach
EVERETT J LAKE

I do wish to say, however, that the State of Connecticut is proud of its Highway Department, and that this department is purely an engineering proposition. The splendid development of the road system in Connecticut is due to the work's having been done by engineers without the help of the politicians.

Our Rivers, Harbors and Bridges Commission, appointed primarily to build the million-dollar dock at New London, had and has largely engineering problems for its consideration.

Among the duties of the Shell Fish Commission are the locating and bounding of the oyster-bed leases by the state, and the engineer is a leading personality in their work.

The law itself requires that three of the six members of our Pollution of Streams Commission shall be engineers.

In our Department of Health the work of the engineer is as much needed and as quickly required in the case of health dangers as is that of the physician.

[1] President Dennison Mfg. Co.

[1] Address of the Governor of Connecticut at a banquet of The American Society of Mechanical Engineers, Hotel Bond, Hartford, Conn. Nov. 3, 1921.

It is in the Engineering Department of the Public Utilities Commission that their most numerous personnel appears.

But I will not continue a catalog of those public offices in which trained engineers must of necessity serve. I will, however, speak of what I shall call the academic angle of my subject.

There are certain fundamental characteristics of a successful engineer, characteristics which he does and must apply to his profession if he be worthy of bearing the name of engineer, and I wish to urge upon you your duties as citizens to apply them in your consideration of the problems of good government and the public weal.

Today we often hear the expression, "Government needs the business man in public office," and if this be true, the need is emphatically for the engineering qualities of the business man.

The first qualification of an engineer is concentration. He must focus on his problem like a burning glass, and not study with the eye and mind of an impressionistic artist.

The next qualification is the power of analysis. The real analytical engineer does not tear apart with ruthless hands and throw into the scrap heap all that comes between him and the point of his ultimate investigation. He rather lays aside in an orderly and tabulated array the covering or by-products, if you will, that they may be again replaced if necessary, or perhaps put to other profitable use.

The third qualification of an engineer is his power of continued application. He learns to work continuously and laboriously.

And a fourth characteristic of the engineer is the quality of thoroughness. He must in his task, in his problem, bring it to completion. A half-finished job is in his domain practically nothing done at all.

These, then, are the fundamentals of a successful engineer, and if he but avoids the one danger of his profession—that of allowing his concentration to restrict his vision, so that in the intense application to any one problem he does not see its full scope or misses an opportunity waiting at his very elbow—he becomes an ideal citizen and one of the great assets of a nation.

You engineers apply these qualities to your life work; I am asking you tonight that you give a little of them to your duties as citizens.

I read recently Fiske's opening chapter of the Beginnings of New England, wherein he describes the growth and transitions of governments.

First the oriental or ancient governments, where a conquering monarch by warfares and struggles conquered and enslaved; then through the Roman Empire and the Holy Roman Empire, when powerful rulers and governments absorbed by conquest but granted citizenship.

Through all of these years, these centuries, we find the people of the world receiving their rights, their liberties, as grants from rulers, expanded or contracted at the will of some individual monarch, or his appointed or self-appointed minister.

Then came those long years of struggle in northern Europe where men were learning self-government and applying that knowledge. One of the hardest lessons to learn was that of delegating governmental functions and yet holding their public officials from transferring their delegated power into personal authority.

With the birth of the United States at our Revolutionary War, the rule of the people was forever established. Forward has been our march both in knowledge of how to govern and our ability to apply that knowledge. So today we who are holding office are but your delegates to turn your desires, your determinations, into laws and enforcements. So, I say it is the duty of all engineers to give a little of their ability, which has made them successful, a little of their time, perhaps an hour every day, to the duties of citizenship.

There are many engineers with all the qualifications of ideal public officials who, when asked to serve, say, "I haven't the time to do it;" what they really mean is that they have not given the time to prepare themselves to do it.

No matter how successful you are in your own business, you cannot be true and square and fair to the state if you cannot or will not take time to study its problems and know what its public officials are doing. With the same technical skill which the engineer, the inventor, the surveyor, the mechanic, puts into his own profession, it is his duty every day to study public life and public affairs so that if the time comes when he is needed by the state he will be prepared for this work.

With the same concentration, the same analysis, the same determination, the same thoroughness that you study and solve the problems of a big machine, a railroad, a river, or an excavation, study and solve the problems of government, municipal and state, and you will provide better than any other class of men a solid, firm foundation for good government. And then with all of our citizenship, see that there is erected upon this foundation a structure of government clean and pure to look at, strong and firm to hold.

EVERETT J. LAKE.

The Metric Controversy

ATTENTION is called to the report recently issued by the National Industrial Conference Board on the Metric Versus the English System of Weights and Measures, and commented on elsewhere in this issue of MECHANICAL ENGINEERING.

A committee representing interests favoring and opposing compulsory metric legislation in the United States have prepared a document which presents the facts regarding this subject in a manner worthy of careful consideration by the entire engineering profession.

The report covers the history and present status of systems of weights and measures in this country, outlines the uses of the metric and English systems in this and other countries and in special fields, and closes with the arguments for and against the substitution of the metric for the English system in the United States.

The report is indeed a notable work and the National Industrial Conference Board is to be highly congratulated for having made such a research and such a well-directed effort in presenting to the public a document of this character. It should do much to clear up the present misunderstanding regarding the controversy, which hinges on the compulsory adoption of the metric system rather than upon the merits of the metric system itself.

CALVIN W. RICE.

Resolution to Prof. W. F. Durand

AT a meeting of the Board of Trustees of the United Engineering Societies held in the Engineering Societies Building, New York, on November 22, a resolution was presented to Prof. W. F. Durand expressing appreciation of his services in connection with the International Engineering Congress of 1915. This Congress, held September 20–25, 1915, during the Panama-Pacific International Exposition at San Francisco, Cal., was sponsored by the following societies, the signatures of whose presidents were affixed to the resolution: American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, American Institute of Electrical Engineers, and Society of Naval Architects and Marine Engineers.

Professor Durand, as chairman of the Committee of Management, assisted by representatives of the societies sponsoring the movement, made all the necessary arrangements for the Congress, which entailed a large volume of work extending over several months. It is estimated that altogether some 750 possible authors of papers or discussions were corresponded with. Papers in foreign languages had to be translated, and papers and discussions had to be edited and revised for publication in proceedings of the Congress, which consisted of ten volumes.

The work of printing and distributing the volumes was partially completed in 1915 but distribution, especially in Europe, was delayed during the war. Professor Durand has carried on the work during these intervening years so that it is now completed and the surplus papers and volumes have been transmitted to the Engineering Societies Library.

The resolution to Professor Durand states, in part, as follows:

"The proceedings of the Congress, issued under your auspices, have come to be recognized as authoritatively portraying the status of engineering practice; and the engineering profession owes you this expression of gratitude for your enterprise, zeal, industry, and patience in the consummation of the work of the International Engineering Congress" held in the year 1915.

Marshal Foch Honored by Four National Engineering Societies

Honorary Membership Conferred upon Ferdinand Foch, Marshal of France, by Civil, Mining and Metallurgical, Mechanical and Electrical Engineering Societies at Joint Meeting in New York, December 13, 1921

IN recognition of his unparalleled service to mankind, Marshal Ferdinand Foch has been unanimously elected to honorary membership in the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, and the American Institute of Electrical Engineers. The presentation took place in the Auditorium of the Engineering Societies Building, 29 West 39th Street, New York, N. Y., on the afternoon of December 13, the day before Marshal Foch sailed for France.

J. Vipond Davies, president of the United Engineering Society, and presiding officer of the meeting, stated the purpose of the gathering and outlined briefly the organization of the four societies and of the United Engineering Society. Col. William Barclay Parsons, commander of the first engineer regiment to go abroad,

THE FOCH MEDAL

delivered a brief address in French, expressing the appreciation of American engineers for the incomparable services rendered by Marshal Foch. He said, in part:

"The art of engineering was defined a long time ago as 'the art of directing the great sources of power in nature for the use and convenience of man.' No better definition can be found today. Of all the sources of power in nature, the greatest, the most valuable, and at the same time the most difficult to direct, is the energy of man himself. He who can direct human energy and turn it to the service of mankind is a great engineer. You, Marshal, have directed a greater mass of human energy than any other man has ever done. And you have successfully directed this mass for the highest uses of mankind, in that you by its aid have pre-

FERDINAND FOCH, MARSHAL OF FRANCE

served for him one of the most precious of human possessions—liberty! Liberty not only for your own illustrious country, but for all the nations of the world."

George S. Webster, president of the American Society of Civil Engineers then made the presentation of one engrossed certificate of honorary membership in all the societies, jointly, and of a case containing emblems of the membership in four societies. In his response, delivered in French, Marshal Foch praised the work of engineers during the war, stating that in moments requiring decision, "the engineer stood out as an essential factor in complete triumph," and expressing his gratitude and that of France for their services. The ceremonies closed with the presentation to the presidents of the four societies of silver replicas of the Foch medal.

This signal honor, the only one of its kind ever to have been conferred, expresses the recognition of these four great societies aggregating a membership of some 45,000, of the ability of Marshal Foch to supplement his military genius with the effective cooperation of the commanders of the armies of five nations and the coördination of their operations that won the war. It forms another bond of union between the engineers of the United States and those of France.

Marshal Foch studied engineering in l'École Polytechnique and l'École d'Application d'Artillerie. He served on the technical section of the Ministry of War early in life, and later was a full professor in l'École de Guerre. The fact that he was not only trained in the applications of engineering to military purposes, but has also taught some of these branches in France's notable war schools and practiced them in the field made him eminently fitted to be, first, Generalissimo of the Armies of the Allies, and later Marshal of France. The victory in which he played so large a part has well been given the name "Victoire de Foch."

Marshal Foch has received many honors. On November 21, 1918 he was elected a member of the French Academy. On the first of December of that year he received the Order of Merit from the King of England and in July, 1919, was given the title of Field Marshal by the King, this being the first instance in which a Frenchman's name was ever inscribed on the active list of the general officers of the British Army. During his recent tour of the United States, city, state and national organizations, educational, governmental and industrial bodies, have united to do honor to the world's greatest soldier.

Announcements of the DeLamater Ericsson Tablet Committee

At a meeting of the DeLamater Ericsson Tablet Committee held November 10, representatives of the twenty societies who have participated in the movement to commemorate the work of Mr. DeLamater and Captain Ericsson were informed of the activities of the Committee to date, and were requested to offer suggestions as to a further program. Those present were requested to have their respective organizations appoint representatives with authority to add to their number as needed to coöperate with the Tablet Committee in developing the tentative program for the ceremonies to occur on March 9, the 60th anniversary of the battle of the *Monitor* and the *Merrimac*. This larger Committee will formulate the details of the final program.

The four tablets which have been designed to mark the sites of the Phoenix Foundry, Captain Ericsson's residence, the DeLamater Iron Works, and the Continental Iron Works, will be unveiled at simultaneous ceremonies taking place on the afternoon of March 9. In the evening there will be a public meeting in a hall or a public dinner in a hotel where addresses will be made.

At the annual dinner of the Capt. John Ericsson Memorial Society of Swedish Engineers, held at the Engineers' Club November 26, Mr. Olaf Rodhe, who had just arrived from Sweden was present and stated his authority to represent the Swedish Engineering Societies of Stockholm in arranging for the celebration on March 9.

"Mining and Metallurgy"

MECHANICAL ENGINEERING extends its congratulations to *Mining and Metallurgy*, admiring as it does its new dress and splendid editorial discussion of timely economic and engineering topics. The presentations are such that a member of the A.I.M.E. is put in touch not only with affairs within the Institute but with what is going on elsewhere in the engineering world, and through these contacts he finds himself in step with the onward march of his profession. MECHANICAL ENGINEERING wishes its contemporary every success.

The "Scientific American"

The new monthly *Scientific American*, a combination of the former weekly *Scientific American* and the *Scientific American Monthly*, show that the best features of the former publications are being combined in the single journal. As a periodical in which both layman and professional scientist will be interested, it contains leading and short articles covering a wide range of subjects, touching on the new and unusual things in scientific discovery in all parts of the world. It contains special departments, among which are several on inventions and patents, mechanical and electrical, engineering, and science notes. The pictorial method of presenting facts, has been retained.

Index to Volume 43 of Mechanical Engineering

An index to Volume 43 of MECHANICAL ENGINEERING is now in the course of preparation, and, it is expected, will be issued the latter part of February. A copy of this index will be sent to each member of the Society or subscriber who sends in a written request therefor. In order that no more copies than are necessary to supply the demand may be printed, requests for copies should be received at headquarters not later than February 15.

The Late Sir Charles Douglas Fox

Sir Charles Douglas Fox, upon whom in 1900 was conferred honorary membership in The American Society of Mechanical Engineers, died on November 13, 1921, at the age of eighty-one. Sir Douglas received his early education at the Cholmondeley School at Highgate, studied at King's College, London, and at the age of 17 was apprenticed to his father, Sir Charles Fox. For two of these apprenticed years he acted as resident engineer in charge of work upon the Witney Railway, and subsequently was with the Ramsey Railway in the same capacity. In 1863 he joined his father's firm as a partner; later his brother, Sir Francis, became a partner, and ultimately the name of the firm was changed to Sir Douglas Fox and Partners, of which firm he was the head at the time of his death.

Sir Douglas Fox's work covered a wide field, for his name was well known in connection with the construction of railways in South Africa and Australia as it was in England. Among his earlier work was the construction of the London, Brighton and South Coast Railway, the Cape Town and Wellington Railway, and the Cape Town-Wynberg Railway. With Sir James Brunlees, he acted as consulting engineer for the Mersey Tunnel. For his work in this connection Her Majesty Queen Victoria conferred the honor of knighthood upon him. He was also connected as joint consulting engineer with the construction of the Liverpool Overhead Railway. This work is unique in England, though on lines similar to the elevated lines in New York City. Sir Douglas and his brother were responsible for the engineering work on the Southern and Metropolitan divisions of the Great Central Railway. He also took a prominent part in underground-railway development in England. In Africa his name is associated with the Rhodesian Railway and the famous bridge over the Zambesi River at Victoria Falls. Other undertakings in South Africa were the Beira Port and Railway, Benguela Railway and the Trans-Zambesi Railway. In South America he was responsible for the construction of railways in the Argentine for the Central Argentine Railway Co.; in Colombia, for the Dorada Railway Co., and also in Brazil.

SIR CHARLES DOUGLAS FOX

He was an enthusiastic advocate of standardization and was one of the early supporters of the movement which resulted in the formation of the British Engineering Standards Committee in 1901 on whose main committee he served from the time of its formation till early in 1920.

Sir Douglas Fox became a member of the Institution of Civil Engineers in 1866, was elected to the council in 1884 and served as its president in 1899-1900. During his term of office he received the American civil and mechanical engineers, who were entertained at the Guildhall on the occasion of their visit to London that year. He was also a member of the Institution of Mechanical Engineers, the Institution of Electrical Engineers, and an honorary member not only of The American Society of Mechanical Engineers but also of the American Society of Civil Engineers. He was a director of some ten companies, was vice-chairman of the South Indian Railway Co., and chairman of the Industrial Dwellings Co. and of the Northfleet Coal and Ballast Co. He patented numerous inventions connected with railway work. In 1880 he was appointed lecturer to the School of Military Engineering, Chatham, his lectures dealing with light and temporary railways. He was awarded at various times by the Institution of Civil Engineers the Manby Premium, the Telford Medal, and Telford Premium for contributions to the proceedings. He was elected a Fellow of King's College (London) in 1887. He was a justice of the peace and took a prominent part in many of the religious and philanthropic movements of the day.

NEWS OF THE F.A.E.S.

JANUARY MEETING OF AMERICAN ENGINEERING COUNCIL

The annual meeting of the American Engineering Council will be held in Washington January 5 and 6. Details of this meeting are not yet available, but the program will include matters pertaining to organization, a review of the past year's activities, and decisions as to future policies. The question of finances will receive special consideration. A recently issued résumé of the activities of the Executive Board stated that although at the time the annual budget was adopted information as to probable expenditures for the fiscal year was necessarily very incomplete, and although unusual demands have been made upon the treasury, the Board has been able to function within the limits of its resources. It has been found, however, that even the moderate dues required for membership have been so high as to prevent several organizations from becoming members of the Federation.

EMPLOYMENT SERVICE

In accordance with a resolution passed at the September meeting of the Executive Board a joint committee of nine, consisting of five members of the Executive Board and a representative from each of the four national engineering societies, has been appointed with power to organize uniform paid employment service for engineers. The members of this committee are as follows: Morris L. Cooke, Chairman, William McClellan, W. E. Rolfe, H. E. Howe, and William B. Powell, of the Executive Board; Richard L. Humphreys, A.S.C.E.; W. M. Corse, A.I.M.E.; Fred J. Miller, A.S.M.E.; and E. B. Craft, A.I.E.E.

The Executive Board has also voted a special appropriation of $2000 for emergency employment work.

ENGINEERING EDUCATION

The Executive Board has received several communications relative to the subject of engineering education. The University of Iowa recommended that the American Engineering Council "establish standards of engineering education for engineering colleges of different grades and rate the engineering colleges of the country in accordance with the classification adopted." A resolution by Mr. W. W. Varney of Baltimore, a member of the Executive Board who has been among those taking a deep interest in engineering-education policies, asked that the Federation appoint "a Committee on Education to consider broadly the training of the engineer and to report on desirable changes in present-day engineering education to better prepare engineering graduates to take their proper places in the profession." Because of these requests, although the Board felt that there were other organizations more directly affected by and concerned with these matters that are giving consideration to them, it has decided to institute appropriate inquiry through a special committee on engineering education. The Committee on Procedure has accordingly appointed Col. A. S. Dwight of New York, Prof. Chas. F. Scott of Yale, and Mr. Varney to study the problem and work out a policy for the F.A.E.S.

Errata

In the paper by Dr. D. S. Jacobus on Boiler and Furnace Economy in the December issue, the temperature mentioned in the fifth line of the third paragraph from the bottom of page 782 was erroneously stated to be 500 deg. fahr. It should read 300 deg. fahr.

The November issue of MECHANICAL ENGINEERING contained an account of a recent snow removal meeting of the Materials Handling Division of the A.S.M.E. in which there were some erroneous statements concerning a device evolved by Edward A. Smith of West Englewood, N. J. The size of the melting chamber of this machine is 67,400 cubic inches instead of cubic feet. Mr. Smith states that at 30 cents per cu. yd., a price which has been paid by the city of New York, it would cost $2,220,000 to remove 7,400,000 cu. yd. of snow, representing an 8-in. fall on approximately 33,000,000 sq. yd. of streets, whereas by using 100 of his machines, and working 28 hours, this amount of snow could be melted for $28,000, including the total operating expenses.

NEWS OF OTHER SOCIETIES

NATIONAL FOUNDERS' ASSOCIATION

The twenty-fifth annual convention of the National Founders' Association was held in New York on November 16 and 17, 1921. At the opening session, President William H. Barr discussed the industrial situation and general causes of present conditions, and A. E. McClintock, commissioner of the association, urged training of forces for future expansion of industry, instruction of employees in principles of economics, and development of a spirit of loyalty within industrial organizations.

Among the speakers at the afternoon session, November 16, were Magnus W. Alexander, Mem.Am.Soc.M.E., on Wage Liquidation in American Industry, and A. C. Davis, on The Present Railway Situation. Mr. Alexander presented charts showing changes in wage rates during recent years, hours worked, percentages of employment, etc., with special reference to foundries and machine shops. These charts are based upon investigations conducted in over twenty industries by the National Industrial Conference Board, of which Mr. Alexander is managing director.

Mr. Davis, vice-president of the Gurney Ball Bearing Company, traced the development of the railroad and discussed some of the measures wherein he believed the solution of some of the present railway problems might be found.

On the second day of the conference the following addresses were presented: Foreman Training, L. V. Hartley, and Foundry Costs, Robert E. Belt. Mr. Hartley, of the Department of Vocational Education of the State of Nebraska, described the project method of training foremen used in that state and showed charts indicating savings in operation costs resulting from the installation of foreman-training courses in various plants.

Mr. Belt, who is secretary-treasurer of the American Malleable Castings Association, gave a paper which dealt with foundry costs, pointing out the importance of an accurate and uniform system and giving the relation of cost to selling price.

An extemporaneous speaker on the first day of the conference was Governor Henry Allen, of Kansas, who gave a brief history of the Court of Industrial Relations in that state. He stated that of the thirty cases decided by the court, twenty-nine have been satisfactory to both employers and labor.

The convention addressed a resolution to the United States Senate urging that railroad regulation be handled by a public tribunal and emphasizing the importance of adjusting all problems without stoppage of service.

AMERICAN IRON AND STEEL INSTITUTE

A memorable meeting of the American Iron and Steel Institute was held in New York on Friday, November 18, 1921. The opening address by Judge Gary, president of the Institute, discussed business conditions, expressed his endorsement of limitation of armament and prophesied prosperous business conditions in the comparatively near future.

Six papers were presented at the professional sessions. John W. Kargarise, of the Edgar Thomson Works, Carnegie Steel Co., Braddock, Pa., discussed improvements in open-hearth port construction, describing early types and giving some of the results of the McKune system and the Venturi and Egler furnaces.

James M. Camp, director of the Bureau of Technical Instruction, Carnegie Steel Co., Pittsburgh, Pa., outlined the relations of the iron and steel and chemical industries.

Thomas J. Foster, chairman of the National Bridge Works, Long Island City, explained the formation of steel lumber and described various types used for building construction. He enumerated the characteristics of steel lumber which make it economical and described tests to which it has been subjected. He stated that residence work, including apartments, is twenty per cent of the total building of this country and that with an ideal steel joist a large share of these structures will be built of steel at a material reduction in price.

Fusion Welding and the Processes in Use were described by S. W. Miller, president of the American Welding Society. He gave the composition of low-carbon steel wire used for gas-welding steel and also of wire for electric metallic-arc welding. Among causes of failures in welded parts he spoke of lack of fusion, both along the

side of the V and in the weld metal itself, and also of the oxidizing action of the water vapor in the gas welding flame and that of the air on the finely divided metal passing through the electric arc. He was of the opinion that nitrogen has no serious effect so far as tensile stress is concerned but that brittleness of welds is due to the presence of oxides.

W. A. Hull, chief of the Refractories Section of the Bureau of Standards, in a paper on Refractories in the Steel Plant, made a strong plea for adequate specifications and coöperation between producer and consumer. A. E. Bourcoud, consulting engineer, New York, discussed a direct process for steel manufacture.

The meeting closed with a banquet in honor of Marshal Foch, at which there were many distinguished guests. After-dinner speakers, besides the guest of honor and President Gary, were Charles M. Schwab and W. D. Guthrie.

Society of Naval Architects and Marine Engineers

The Society of Naval Architects and Marine Engineers held its twenty-ninth general meeting in New York Thursday and Friday, November 17 and 18, 1921. Thirteen papers were presented at four professional sessions. One of these sessions was a joint meeting with the American Institute of Electrical Engineers, at which W. E. Thau, general engineer for Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa., presented a paper on Electric Propulsion of Ships, and E. D. Dickinson, mechanical engineer of the Marine Department of the General Electric Company, Schenectady, N. Y., spoke on Electric Auxiliaries on Merchant Ships.

Among the subjects discussed at other sessions were The Tactical Relations between Different Classes of Men of War and Their Embodiment in Design; Development of the Three-Plane Navy, With or Without Battleships; How Can American Ships Compete Successfully with Foreign Ships; The Importance of Port Facilities in the Development of Merchant Marine and Commerce; American Apprenticeships, Schools and Scholarships; and Design and Construction of Passenger Steamers.

Special arrangements were made for the convenience of those members desiring to view the exhibition of the Marine Equipment Association of America held in New York during the week of November 14–19. The most modern auxiliaries and equipment installed on board ships as well as illustrations of various new methods in shipbuilding work were displayed at this exhibition.

The Taylor Society

The Taylor Society held its annual meeting in New York, Dec. 1, 2 and 3. The first public session, held Thursday evening, December 1, was devoted to an examination of the evaluation sheet devised and used by the Committee on the Elimination of Waste in Industry. The technique of the method employed by the committee was discussed by a large number of engineers who coöperated in the investigation.

There were two sales executives' sessions on the second day of the conference, one devoted to the report of the Committee on Sales Engineering and one to a paper on the necessity of the quota for proper sales cost accounting. There was also a plant managers' session, with a paper by C. F. O'Connor, production manager of the Universal Winding Company, Providence, R. I., and discussion of maintenance of a system of operations under varying conditions by Carl G. Barth, Wilfred Lewis, William O. Lichtner, R. G. Scott, and other engineers well fitted to deal with problems of scientific management.

At an office managers' session it was shown that such fundamental principles of scientific management as precise control of routine operations, standardization the basis of control, and investigation and experiment the basis of standardization, can be applied to offices as well as shops.

The evening session on December 2 dealt with the general control of business. In a paper presented by John H. Williams, of Day & Zimmermann, Philadelphia, it was shown that any precision in general control rests upon the foundation of precision in the details of operating organization and control. This session was planned by the Taylor Society in order to bring out discussion which may be used as a guide in its study on the problem of general administrative control. This study is being conducted by a special committee appointed by the society.

On December 3 there was a plant managers' session and a labor managers' session. The first was devoted to a study of combination routing to meet the problems of small quantities and short operations. The second presented an analysis of the elements which make a good worker and of the forces which influence these elements.

The meeting closed with a luncheon in honor of Henry R. Towne, honorary president of the Taylor Society. Addresses by Mr. Towne, Wilfred Lewis, president of the Tabor Manufacturing Company, Philadelphia, and Calvin Rice, secretary A.S.M.E., were reminiscent of the early days of scientific management and of Frederick W. Taylor, of whom Mr. Towne was always a strong supporter.

RADIO SHIP CONTROL

(Continued from page 44)

neering. Its success was pronounced from the start, but as with the first tests of all such apparatus, it was found that some of the parts were too sensitive, and more rugged ones were developed under the direction of the officers of the Battleship *Ohio*. Simplification of the equipment was also effected in the same manner.

PROCESS CHARTS

(Continued from page 41)

5 Motion study

6 Micromotion studies and chronocyclographs for obtaining and recording the One Best Way to do Work.

c Make process chart of the process as finally adopted as a base for still further and cumulative improvement.

Note that—

a Visualizing processes does not necessarily mean changing the processes

b Process charts pay.

CODE FOR DISPLACEMENT COMPRESSORS AND BLOWERS

(Continued from page 48)

(62)	Temperature of steam leaving steam receiver, if superheated	deg. fahr.
(63)	Temperature of steam in exhaust pipe as observed	deg. fahr.
(64)	Temperature of saturated steam in exhaust pipe corresponding to pressure in exhaust pipe	deg. fahr.
	Total Quantities	
(70)	Superheat, at throttle	deg. fahr.
(71)	Moisture in steam	per cent.
(72)	Total steam and water consumed by engine as measured	lb.
(73)	Total steam less water consumed	lb.
(74)	Correction factor conforming to conditions agreed upon	lb.
(75)	Equivalent total steam consumed, conforming to conditions	lb.
	Unit Quantities	
(76)	Steam and water (or superheated steam) consumed per hour as measured	lb.
(80)	Steam less water (or superheated steam) consumed per hour	lb.
(81)	Equivalent conforming to conditions consumed per hour	lb.
	Power Input	
(90)	Steam cylinder—Indicated horsepower developed, whole engine	i.hp.
(91)	High-pressure steam cylinder, crank end	i.hp.
	head end	i.hp.
(92)	Low-pressure steam cylinder, crank end	i.hp.
	head end	i.hp.
	Economy Results	
(105)	Steam less water (or superheated steam) consumed per i.hp-hr. (Item 80÷Item 90)	lb.
(106)	Equivalent steam consumed per i.hp. (Item 81÷Item 90)	lb.
(107)	Steam less water (or superheated steam) consumed per 100 cu. ft. of air or gas compressed at intake pressure and temperature (100× Item 73÷Item 67)	lb.
(108)	Equivalent steam consumed per 100 cu. ft. of air or gas compressed at intake pressure and temperature (100×Item 75÷Item 67)	lb.

TABLE 4 ADDITIONAL ITEMS APPLYING ONLY WHEN THE DRIVING ELEMENT IS AN INTERNAL-COMBUSTION ENGINE

(The items of this table will be developed upon the completion of the Test Code for Internal-Combustion Engines.)

Metric vs. English System of Weights and Measures

Review by Luther D. Burlingame, Chairman of the A.S.M.E. Standing Committee on Weights and Measures, of Research Report No. 42 of the National Industrial Conference Board

OWING to the continued discussion of the question of the adoption of the metric system in this country, to supplant the established system of weights and measures, a joint committee was appointed by the National Industrial Conference Board to represent interests favoring and opposed to the adoption of the metric system in the United States, with the idea of making a thorough and impartial investigation of the situation, and publishing the results in order that a basis may be had for an intelligent decision not only by the affiliated organizations making up the National Industrial Conference Board, but by the public at large. The following Committee has served:

E. M. HERR, *Chairman*, president of the Westinghouse Electric & Mfg. Co.

FRED J. MILLER, past-president of The American Society of Mechanical Engineers

HENRY D. SHARPE, treasurer, Brown & Sharpe Mfg. Co.

HENRY R. TOWNE, chairman of Board of Directors, Yale & Towne Mfg. Co.

FRANK O. WELLS, formerly president of the Greenfield Tap & Die Co.

Under the supervision of this Committee the investigation was carried on through trained employees of the National Industrial Conference Board, and has resulted in the publication of a report of 261 pages, divided into three parts:

I History and Present National Status of Systems of Weights and Measures

II Use of Metric and English Systems in Special Fields

III Arguments for and against the Substitution of the Metric for the English System in the United States.

Part I gives first the origin of the English and other natural systems, showing how our present system has developed from the needs of men, and has become adapted to fundamental trades and industries. The history of the origin and development of the metric system follows. The present status of the two systems is then compared, showing the number of countries and population of each where the English and metric systems respectively predominate, and their relative percentages to other countries where neither predominates. This analysis shows that the English system predominates in twelve countries with a population of nearly 350,000,000, while the metric system predominates in thirty-seven countries with a population of nearly 400,000,000, the combined total, however, being less than half the population of the world, this "larger half" being listed as having neither the English nor the metric system predominating.

This part of the report deals with many of the South American countries which were considered in a paper entitled, The Weights and Measures of Latin America, presented by Mr. F. A. Halsey before the A.S.M.E. at the Annual Meeting in December, 1918; and it is interesting to compare the findings of the investigators of the National Industrial Conference Board with those in Mr. Halsey's paper. While Mr. Halsey goes much more into detail as to the lines of industry and manufacture where the various systems are used, the general trend of the present report follows very closely the findings as shown by his investigation, and countries which were reported by him as showing least progress toward the metric system in actual use, are classed as doubtful.

Under the heading Weights and Measures in the United States the present situation is summarized clearly and holds the issue up squarely to the American public, as follows (page 42 of the report):

> The situation in the United States, however, is today quite different from the situation that confronted other important countries in making a change from their local systems to the metric. In other countries considerable confusion of weights and measures existed at the time the change was brought about. In other countries, also, the change took place before the industrial life of the nation had become organized and standardized to the extent that modern production makes necessary. The countries outside of Europe which have adopted the metric system have little or no organized industry in the modern sense.
>
> In the United States today there is, in the first place, no fundamental confusion with respect to weights and measures. Furthermore, the United States unquestionably stands in the forefront of the great industrial and manufacturing nations. Its highly organized industry is based on the English units of weight and measure, and most of its vast technical literature is written in this system. All things considered, therefore, there does not exist in this country the great incentive to a change found in other nations where confusion was the rule until the metric system was adopted.
>
> In consequence the situation today narrows itself down to the question whether the advantages to be gained warrant the compulsory adoption of one unified system, namely, the metric, in the place of another unified system, namely, the English, which latter is moreover the established system and enters so intimately into the present industrial organization of the nation. It is not a question of allowing the use of the two systems side by side and giving the metric the opportunity of supplanting the English, because the metric has, as a matter of fact, been a legal system in the United States since 1866, and any one who so desires and finds it more convenient and practical may use it. The question is, shall the United States discard the English system of weights and measures entirely and absolutely and in its place substitute by compulsory law the metric system as the sole standard?

The report includes arguments for making the change and the reasons on which these arguments are based. These statements with their opposing arguments are both strongly presented.

USE OF METRIC AND ENGLISH SYSTEMS IN SPECIAL FIELDS

Part II opens with the statement that "a nation is made up of a number of special fields of activity, in which the question of a change in weights and measures plays a little or a greater part, depending on the nature of the field and the ease or difficulty with which a change from an established to another system can be accomplished," and introduces a series of questions to be answered, such as:

1 Has a given field had its origin and development in a certain country and then spread to the rest of the world, carrying with it the weights and measures of the country of origin?

2 Does the position an industry has achieved and now holds center about standardized practices, with respect to weights and measures, built up after years of effort, and would the destruction or alteration of these practices virtually mean the giving up of the prominent place held by the industry?

3 Is the scope of a certain field limited and local, as in agriculture or mining, or international?

4 Are the weights and measures written into the very fabric of the institutions, implements or records existing in a certain field?

5 What is the relative importance of one field as against another?

6 How much demand is there for a change?

The report then goes on to analyze these various issues and to give a background, so that an intelligent answer can be given to each of these questions, under the following headings:

1 *Science and Engineering*, under which are discussed chemistry, medicine and pharmacy, electrical, mechanical, and civil engineering, etc. This division is thus summarized:

> A considerable demand for a change in systems of weights and measures in the United States comes from the scientific group and from those engaged in the manufacture of refined instruments and products, but this sentiment is not shared very much by the engineering professions. . . . . Even though this group were unanimously in favor of a change, its size is small as compared with such fields as agriculture, mining, manufacturing, and trade, and it would suffer no hardship through a change, while these others would.

2 *Agriculture, Mining, Transportation and Trade.* After an analytical and statistical discussion, it is summarized thus:

> In the four fields treated in this chapter, such little demand as exists for a change to the metric system comes from those engaged in wholesale trade, who, as has been noted, comprise a very small group, comparatively speaking. There is practically no sentiment at all in favor of a change to be found in the other fields discussed.

3 *Manufacturing*, including textiles, metal products, food products, lumber, paper and printing, leather and its finished products, etc. The summary of this part of the investigation states that:

> The survey in this chapter of various specific manufacturing industries serves to indicate how intimately weights and measures are tied up with the products of manufacture and how widely English units are used in various industries the world over.

The report cites specific instances to illustrate this, and continues:

Over 90 per cent of the metal-products industry registered decided opposition to a change. The food-products industry showed similar opposition. The lumber industry was likewise opposed and emphasized "the great confusion and incalculable expense" that would result. The paper and printing, automobile, railway car, shipbuilding, and implement and vehicle industries also went on record as decidedly adverse to any change.

The manufacturing field, employing as it does over 10,500,000 workers, and producing commodities valued at something like $25,000,000,000 annually, is unquestionably one of the most important fields of industry in the United States. The indications are that a compulsory change to the metric system would profoundly affect many manufacturing lines especially during the period of transition, which the experience of other countries suggests would be very long. The interests and desires of such an important field and the effect of a change in weights and measures upon it should naturally be carefully weighed in considering the advisability of a compulsory change.

4 *Foreign Trade.* Much attention is given to an analysis of world trade, and the arguments pro and con, as to whether a change to the metric system would be of appreciable benefit to the foreign trade of this country. The figures show that 48.2 per cent of the world's export trade is now transacted by English countries, 37.5 per cent by metric countries, and 14.3 per cent by other countries. This indicates that while more than half of the population of the world is included under the heading "other countries," the total amount of foreign trade which they represent is a very small percentage of the total.

The graphic diagrams shown in the report make very clear the relative importance of the different elements which have an influence on this discussion, and the above ratios are shown in one of these diagrams. (Page 105).

Another diagram (page 113) shows the exports of the United States to English countries as 41.9 per cent, to Latin-American English and other countries, 5.7 per cent, to European metric countries 37.1 per cent, to Latin-American metric countries, 6.3 per cent, and to all other countries, 9 per cent.

ARGUMENTS FOR AND AGAINST THE SUBSTITUTION OF THE METRIC FOR THE ENGLISH SYSTEM IN THE UNITED STATES

Part III is in the nature of the lawyers' pleas on each side of a case before a court, and is of value as showing opposing views strongly expressed. It is divided under the headings:

1 Intrinsic Merits of the Metric and English Systems
2 Advantages and Use of Metric as Compared with the English System in Special Fields
3 Practicability of Making a Compulsory Change
4 Extent and Character of Demand for such a Change
5 Comparison of Metric and English as Universal Systems.

The arguments pro and con under these headings are presented in such a way that they are in the nature of a spirited debate, and any one who is even casually interested in great issues before this country would be not only instructed but greatly interested in carefully following the discussion. (The report may be obtained from The Century Company, New York, at $2.50 a copy.)

It is believed that with the metric question again before a congressional committee and the issue being raised before great national organizations throughout the country, a careful study of this report will help to insure sound judgment in coming to such a decision as will place the influence of the reader on the side of this momentous question where it will count to support that policy which will be for the best interests of the American people.

Waste in Industry

WASTE IN INDUSTRY. By the Committee on Elimination of Waste in Industry of the Federated American Engineering Societies. First edition, 1921. Published by Federated American Engineering Societies, Washington, D. C. McGraw-Hill Book Co., Inc., New York, selling agents. Cloth, 6 × 9 in., 409 pp., charts, tables, $4.

REVIEWED BY JOSEPH W. ROE,[1] NEW YORK, N. Y.

WHILE many have been attacking the problems of waste in specific industries with steadily increasing effect, no qualified agency has heretofore attempted to do so for Industry as a whole.

One of the first acts of Mr. Herbert Hoover, as first president of the Federated American Engineering Societies, was the appointment of a committee of engineers to undertake this, and the book in hand is their formal report. The purpose was to gather concrete information, to stimulate action, and lay a foundation for other studies. No attempt was made at an academic definition of waste. It has been treated as the difference, in material, time and effort expended in production, between average practice and the best known practice; and the committee has undertaken to evaluate this difference. Its first work was to set up units and methods of measurement which could be applied to all the industries studied. This is something new and of great possibilities. With this in view a very complete questionnaire was prepared and used as a basis for a trial study of one plant in each industry. The results of these studies were brought together, reviewed by the committee and a revised questionnaire developed, which was used in all subsequent work. The quantitative comparison between different industries was made through use of a point system on "evaluation sheets," these sheets having the same grouping of information as the questionnaire, and with definite, careful instructions as to the method of arriving at the totals. The totals indicate waste in comparison with the best existing practice. Both the questionnaire and the evaluation sheets are given in full and are one of its most valuable parts of the report.

This method of rating by points supplies a common ground for the findings of 50 engineers, covering 125 plants, in 6 industries. While it cannot eliminate variations of judgment in evaluating the different elements, it makes sure that the same method is used in all cases, also that the same elements are considered and in the same relationships.

[1] Professor of Industrial Engineering, New York University. Mem. Am. Soc.M.E.

There is no hesitation in saying that the study affords the best information we have to date. It makes no claim to minute accuracy, but it does to substantial accuracy. The broad findings are summarized in the Tables 1, 2 and 3.

From Table 1 are derived percentage values for each of the agencies against which responsibility is assessed, as in Table 2.

TABLE 1

Industry Studied	Responsibility Assayed Against Management, Points	Responsibility Assayed Against Labor, Points	Responsibility Assayed Against Outside Contacts (The Public, Trade Relationships, and other Factors), Points	Totals, Points
Men's Clothing Mfg.	48.33	10.50	4.95	63.78
Building Industry	34.30	11.30	7.40	53.00
Printing	36.36	16.25	5.00	57.61
Boot & Shoe Mfg.	30.25	4.85	5.83	40.93
Metal Trades	23.23	2.55	2.88	28.66
Textile Mfg.	24.70	4.70	19.80	49.20

TABLE 2

Industry Studied	Responsibility Assayed Against Management, Per Cent	Responsibility Assayed Against Labor, Per Cent	Responsibility Assayed against Outside Contacts (The Public, Trade Relationships, and other Factors) Per Cent
Men's Clothing Mfg.	75	16	9
Building Industry	65	21	14
Printing	63	28	9
Boot & Shoe Mfg.	73	11	16
Metal Trades	81	9	10
Textile Mfg.	50	10	40

TABLE 3

Industry	Points Assayed Against the Best Plant Studied	Points Assayed Against the Average of all Plants Studied	Ratio Best to Average
Men's Clothing Mfg.	26.73	63.78	1 : 2
Building Industry	30.15	53.00	1 : 1½
Printing	30.50	57.61	1 : 2
Boot & Shoe Mfg.	12.50	40.83	1 : 3
Metal Trades	6.00	28.66	1 : 4½
Textile Mfg.	28.00	49.20	1 : 1½

In every industry there are outstanding examples of good management. Table 3 gives a comparison of the best plant in each industry studied, with the average of the plants.

These tables embody the general findings developed throughout the report. The results have surprised the general public, but not those familiar with management problems. Management has

the greatest opportunity and responsibility for eliminating waste. Labor has an important part, though smaller in proportion. The public also has a part, but less clearly defined and far more difficult to rectify. In many cases it involves change of habits and tastes. It is all very well to talk of a reduction in the numbers of styles, but only a nervy man would tell his best girl that standardization requires her to wear her last year's hat a second winter; and the worst of it is, he would quit loving her if she did.

The first of the three sections is a summary of the detailed reports, covering the sources and causes of waste, recommendations for elimination, and a description of the questionnaire and the evaluation sheet used.

The second section contains the reports of the six industries studied—the building trades, men's ready-made clothing, shoe manufacturing, printing, metal trades and textile manufacturing.

The third section comprises seven general reports, covering unemployment, strikes and lockouts, legal machinery for adjusting disputes, industrial accidents, health of industrial workers, eye conservation, and purchasing and sales policies. These are statistical in nature, but all have constructive suggestions for betterment.

This book should be read by every man in a position of industrial responsibility. It is full of matter challenging attention and maintains throughout a constructive attitude. The method of gaging wastes is especially suggestive and forms a yardstick by which a manager can measure waste in his own industry and in many cases establishes a basis of comparison which may prove a great help. The yardstick may be crude, but until a better one is devised, valuable comparative results can be obtained if everybody uses the same stick.

Book Notes

ANNALS OF THE AMERICAN ACADEMY OF POLITICAL AND SOCIAL SCIENCE. May 1920. Paper, 6 × 9 in., Vol. 89, No. 178. 289 pp., $1.25.

This volume of essays discusses the economic significance of present-day prices, price factors in typical commodities, wages, profits and excess profits taxes, production, coöperation, international finance and trade in their relation to prices, inflation and prices, and the world's monetary problems. The papers included are by well-known economists, business men and engineers.

BLEACHING. By S. H. Higgins. Longmans, Green & Co., New York, 1921. (Publications of the University of Manchester, No. 142.) Cloth, 6 × 9 in., 137 pp., $3.75.

The idea of this volume is not to give an account of the subject of bleaching, but to act as a supplement to other books, of which there are many, dealing with this industry. The author's intention has been to discuss the important researches of recent years bearing on bleaching as a basis for further research.

CENTRAL STATION RATES IN THEORY AND PRACTICE. By H. E. Eisenmenger. Frederick J. Drake & Co., Chicago, 1921. Fabrikoid, 5 × 7 in., 382 pp., illus.

A textbook for students of electric rates, intended to meet the needs of both beginners and experts. Discusses the cost of electric service, its price, systems of charging, rate analysis, the accuracy of rates and public regulation of public utilities. Appeared serially in the *Electrical Review*.

CENTRIFUGAL PUMPS. By J. W. Cameron. Scott, Greenwood & Son, London, 1921. Cloth, 6 × 9 in., 142 pp., illus., $3.75.

This small book discusses the theory of these pumps, hydraulic losses, hydraulic efficiency, bearings, effect of vane angle on efficiency, pump details, axial thrust balancing, calculation and design of pumps, and commercial types. The work is intended for engineers and draftsmen.

LES COMBUSTIBLES LIQUIDES ET LEURS APPLICATIONS. By the Syndicat d'Applications Industrielles des Combustibles Liquides. Gauthier-Villars et Cie, Paris, 1921. Cloth, 4 × 6 in., 621 pp., illus.

This handbook, published by an association of French companies interested in the production and use of liquid fuel, has been prepared as a practical guide to users and dealers. It includes the regulations governing the importation and use of liquid fuels, insurance laws, brief descriptions of the chief oil-producing countries, the principal fuel oils and lubricants and methods for testing them. Descriptions of the leading French types of internal combustion engines, furnaces and boilers are given, and directions for storing and shipping oil. The final section consists of conversion tables and coefficients.

CONDENSED CATALOGUES OF MECHANICAL EQUIPMENT. Published by The American Society of Mechanical Engineers, New York, 1921. Eleventh annual volume. Cloth, 6 × 9 in., 932 pp., illus., $4.

The eleventh issue of this convenient collection of commercial data upon mechanical equipment and accompanying directories of manufacturers and consulting engineers follows the form of preceding editions. It has, however, been enlarged considerably and revised carefully. Four thousand firms are listed, under 3000 classes, and 495 of these have published data about their products in the book. The number of consulting engineers is 1000, classified under 400 lines of specialization.

ELEKTRISCHE FOERDERMASCHINEN. By W. Philippi. S. Hirzel, Leipzig, 1921. Paper, 6 × 9 in., 304 pp., illus.

The use of electric hoisting machinery in mining is covered from several viewpoints, mechanical, electrical and economic, with special stress upon the last aspect of the question. The question, whether electric hoisting shall be adopted for a given mine, is the one to which most attention is given.

EMPLOYMENT MANAGEMENT, WAGE SYSTEMS AND RATE SETTING. First edition. The Industrial Press, New York, 1921. Paper, 6 × 9 in., 103 pp., $1.

This concise description of systematic methods of employing and placing men, and of wage-payment systems, is based on articles that have appeared in *Machinery*, describing the practice in the Westinghouse Electric and Manufacturing Company, R. K. LeBlond Machine Tool Company, Norton Company and other manufacturing plants.

DIE FORDERUNG VON MASSENGUTERN. By Georg von Hanffstengel. Vol. 1. Julius Springer, Berlin, 1921. Cloth, 6 × 9 in., 306 pp., illus., 234 M.

Volume one of the third edition of this useful treatise deals with belt, chain, bucket, screw, spiral, pneumatic and hydraulic conveyors, together with some minor types. The text is practical as well as theoretical, and covers modern practice very thoroughly. The work has been thoroughly revised.

GRAPHICAL METHODS. By William C. Marshall. First edition. McGraw-Hill Book Co., Inc., New York, 1921. Cloth, 6 × 9 in., 253 pp., charts $3.

A general treatise on the construction and use of graphical charts. Includes charts intended to appeal to the general public, those of interest to executives and those intended to facilitate engineering and scientific calculations. Gives many examples of the application of charts to a great variety of purposes and contains an extensive bibliography of published charts.

STEAM ROAD VEHICLES. By L. M. Meyrick-Jones. Second edition. Iliffe & Sons, Ltd., London. Cloth, 6 × 8 in., 213 pp., illus., 5 s.

This book is intended to provide an explanation of the theory and practice of steam-road transport, suited to the needs of owners and as an instruction book for drivers and mechanics. Its twenty-eight chapters describe the principles involved in the generation of steam and the construction of the various units that make up the vehicle. This edition has been revised and enlarged. The practice described is exclusively British.

OIL-FIELD PRACTICE. By Dorsey Hager. First edition. McGraw-Hill Book Co., Inc., New York, 1921. Fabrikoid, 5 × 7 in., 310 pp., illus., diagrams, $3.

The subjects treated in this volume are the acquisition of lands, development drilling, development production methods, transportation, storage, fires, avoidable wastes and losses, refining methods, valuation and buying, and general observations on the industry. The appendix contains sample forms for records, useful tables and a glossary. The book presents American methods of developing oil properties and is intended to give an intelligent insight into the petroleum industry as a whole. To a certain extent it supplements the author's earlier work, Practical Oil Geology.

COMPOUNDING THE COMBUSTION ENGINE

(Continued from page 32)

under complete control. In one instance the clutch succeeded in suppressing entirely a very serious "critical" which occurred in a 700-hp. submarine type Diesel near the normal running speed.[1]

SAVING IN WEIGHT AND SPACE OVER DIESELS

In Fig. 13 there is shown in side elevation to the left, and end elevation to the right, the comparison between the compound divided-unit geared drive delivering to the tail shaft the same power and speed as the standard Diesel unit of the largest manufacturer. The divided unit consists of two engines, each with four combustion cylinders, in two compound units. Note each of these engines gives the same turning moments and torque diagram as an eight-cylinder Diesel. In fact, with this divided unit we have eight combustion cylinders in the two engines with less than half of the cams, etc., of a six-cylinder Diesel, with all the advantages of two engines, including immunity from shutdown, possibility of inspection and other operating advantages which are well recognized. These two views serve graphically to give some idea of the saving in weight and space.

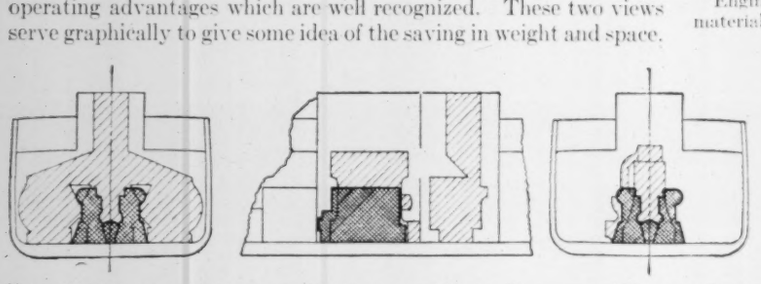

FIG. 14 COMPARISON BETWEEN RECIPROCATING STEAM PLANT AND GEARED COMPOUND DIESEL ENGINE

To aid in the comparison with the reciprocating steam engine, Fig. 14 has been developed, giving three views of the steam plant in shaded background. Against it there is outlined the standard compound, two-engine, geared magnetic-clutch arrangement for the identical horsepower and speed at the tail shaft.

PRESIDENT CARMAN'S ADDRESS

(Continued from page 8)

Moral, the Political, and the Economic. I briefly define them as follows:

The Moral Law: God's Law, immutable, unchanging

The Political Law: Man's Law, continually changing

The Economic Law: The Law resultant from the two others.

These laws are coexisting. Their scientific application and operation is necessary, and to have an equilibrium all of them must function properly and in harmony, just as the various parts of a properly working machine must all function. There is a relationship existing between these laws just as definite as the proportional relationship existing between the elements that go to make up the strongest bar of steel, the parts of a completed machine, or the departments of a well-organized and successfully operating business.

The Political and Economic Laws *must* conform to the Moral Law, it is the basic law—and only in this way will complete harmony be secured. These three laws have all been and are in continuous operation but they fail to function as a unit, and their independent operation has produced the chaotic conditions existing today.

There has been much effort in the last decade to solve the problems of so-called "Industrial Relations." Many plans have been advanced and tried, and while there has been some improvement, nevertheless these plans have fallen far short of their goal. Let me lay special stress on this fact, for any effort and endeavor is predestined to failure unless its fundamental principle conforms to each and all of these laws. The world has been asking for thousands of years, "Am I my brother's keeper." The answer comes back through the ages, "Yes," "Love thy neighbor as thyself."

[1] See the *Sperryscope*, vol. 2, no. 9.

What is the remedy? There must be a speedy adjustment of affairs vital to mankind; we must secure a recognition of and obedience to all of these laws or we will soon be in the midst of the greatest conflict of all ages. We are only just beginning to admit that here is the source of most of the difficulties that we have today.

If civilization is to continue, and I am sure it is, this complete conformity must be sought for, found, accepted, and reduced to practice. If the search is not to be made by engineers, then it must be made by some other group of men or by some one man. The world awaits the solution, men's eyes are turned, looking with expectancy, some hopefully, some fearfully. They long for peace, the peace that will come only when this age-old struggle between Capital and Labor has ceased.

Engineers, even though this message has been heralded throughout the land, are slow to accept the challenge to further serve mankind. They are seemingly content to perform only a part of the work for which they have prepared.

The Federated American Engineering Societies, speaking for the American Engineers, thus defined "Engineering:"

> Engineering is the science of controlling the forces, and of utilizing the materials of nature for the benefit of man, and the art of organizing and directing human activities in connection therewith.
>
> As service to others is the expression of the highest motive to which men respond and as duty to contribute to the public welfare demands the best efforts men put forth—Now, therefore . . . .

If we accept this definition, and as a Society we have already done so, then we cannot escape our duty. The door is open wide. The opportunity for service is before us, a service greater by far than the glorious achievements of the past, an opportunity of weaving together the forces and materials of nature and human efforts into a composite, yet unified and synchronized unit of production, operating with satisfaction to the worker, to the capitalist, and for the benefit of all mankind.

DISCUSSION OF THE POWER WASTE SESSION

(Continued from page 26)

higher steam pressures and temperatures, said that the ideal in station design and operation was the lowest cost of current consistent with reliability. Until the price of coal is much higher, steam pressures will remain practically as at present. The study of the heat balance problem with respect to varying load factor, as emphasized by Mr. Pigott, was important, he said, and in selecting the Colfax system one was chosen which appeared to be the most flexible, most reliable, and to cover the greatest variety of operating conditions. In reply to a statement that control of duplex drive auxiliaries was difficult, he said that this was not so if proper attention were paid to the units. The question of repeating the existing installation, raised by Mr. Scott, was being answered at the Colfax Station by a duplication of the original system of heat balance in a second unit which is now being put in.

C. Harold Berry said that the figures in his paper were for an assumed rather than an actual case, the object being to define the problem, rather than to solve it. It would be interesting, as Mr. Pigott had pointed out, to make such an investigation for varying load factors. The question of duplicating the existing equipment at Conners Creek was answered by the present efforts to change auxiliaries to a direct-current drive for better speed regulation, and the probable installation in the future of economizers.

J. H. Lawrence pointed out the impossibility, in New York, of storing a sufficient quantity of fuel oil for such a station as that at Hell Gate. He had never known of trouble with duplex drive.

In answer to a statement made by Mr. Pope about the danger of overspeeding a turbine at light loads when receiving low-pressure steam in the lower stages, he explained that such connections to turbines in the Hell Gate plant were designed to close with the closing of the main steam valve and prevent over-speeding.

THE ENGINEERING INDEX

(Registered U. S. Patent Office and Canadian Patent Office.)

THE ENGINEERING INDEX presents each month, in conveniently classified form, items descriptive of the articles appearing in the current issues of the world's engineering and scientific press of particular interest to mechanical engineers. At the end of the year the monthly installments are combined along with items dealing with civil, electrical, mining and other branches of engineering, and published in book form, this annual volume having regularly appeared since 1906. In the preparation of the Index by the engineering staff of The American Society of Mechanical Engineers some 1200 technical publications received by the Engineering Societies Library (New York) are regularly reviewed, thus bringing the great resources of that library to the entire engineering profession.

Photostatic copies (white printing on a black background) of any of the articles listed in the Index may be obtained at a price of 25 cents per page, plus postage. A separate print is required for each page of the larger periodicals, but wherever possible two small or medium-sized pages will be photographed together on the same print. The bill will be mailed with the print. When ordering photostats identify the article by quoting from the Index item: (1) Title of article; (2) Name of periodical in which it appeared; (3) Volume, number, and date of publication of periodical; (4) Page numbers. Orders should be sent to the Engineering Societies Library, 29 West 39th Street, New York.

ABRASIVE WHEELS

Selection of. The Proper Selection of Grinding Wheels. P. N. Cooke. Can. Machy., vol. 26, no. 15, Oct. 13, 1921, pp. 25-28. Development and advantages of modern artificial abrasives; grain and grade; manufacturing processes; production grinding; relation of work to grain and grade.

ABRASIVES

Sizing Materials. Sizing of Abrasive Materials. William P. Butler and Paul Keever. Abrasive Industry, vol. 2, no. 10, Oct. 1921, pp. 337-339, 5 figs. Wire sizes and mesh openings of abrasive sizing screens should be standardized to insure classification of uniform grain sizes. (Abstract.) Paper presented before Grinding Wheel Manufacturers' Assn. of U. S. & Canada.

ACCOUNTING

Records for Consulting Engineers. Accounting Records for Consulting Engineers. Arthur L. Mullergren. Eng. News-Rec., vol. 87, no. 17, Oct. 27, 1921, pp. 685-687, 3 figs. Arguments for keeping books with segregated costs. Details of loose-leaf system. Forms for expense vouchers and time distribution.

AIR

Specific Heats. The Ratio of the Specific Heats of Air and of Carbon Dioxide. J. R. Partington. Proc. Roy. Soc., vol. 100, no. A702, Oct. 4, 1921, pp. 27-49, 2 figs. Results of experiments on the lines of Lummer and Pringsheim method, eliminating their systematic errors or bringing them under control.

AIR COMPRESSORS

Electrically Driven. Double-Acting Two-Stage Air Compressor. Engineering, vol. 112, no. 2915, Nov. 11, 1921, pp. 674-676, 16 figs. Believed to be largest compressor ever built in Sweden. Driven by directly coupled electric motor, rotor of which is actually mounted on crankshaft. Delivers compressed air to mines.

AIR FURNACES

Firing Method. Equips Air Furnace with Hopper. Iron Trade Rev., vol. 69, no. 17, Oct. 27, 1921, pp. 1082-1084, 4 figs. Coal is dumped into hopper which feeds a specially designed grate as coal is consumed. Only manual labor necessary is that required for pulling the ashes. Method adopted by Allis-Chalmers Mfg. Co.

AIRCRAFT CONSTRUCTION MATERIALS

Fabrics. Permeability of Balloon Fabrics (La Permeabilité des tissus pour ballons). A. D. Ritchie. Révue Universelle des Mines, vol. 10, no. 6, Sept. 15, 1921, pp. 621-631. Discusses rubberized materials and tests made with them.

Spruce. Investigation of Crushing Strength of Spruce at Varying Angles of Grain. Air Service Information Circular, vol. 3, no. 259, July 15, 1921, 15 pp., 10 figs. For determination of crushing or compressive strength from 0 to 90 deg.

AIRPLANE ENGINES

Improvements. Aero Engines, Alan E. L. Chorlton. Jl. Roy. Soc. Arts, vol. 69, no. 3591, Sept. 16, 1921, pp. 725-740, 2 figs. Discusses thermodynamical, mechanical and metallurgical progress made in construction of aeroengines; stratified working, regeneration, bearing loadings and load factors, two-cycle engines, etc.

AIRPLANE PROPELLERS

Theory. The Modern Theory of Aerofoils and Propellers (Die neuere Theorie der Tragflügel und Luftschrauben). E. Everling. Zeit. des Vereines deutscher Ingenieure, vol. 65, no. 44, Oct. 29, 1921, pp. 1142-1143. Investigation of lift and drag based on works by E. Trefftz and R. Fuchs in Zeit. für angewandte Mathematik u. Mechanik, nos. 3 and 2.

The Prandtl Aerofoil and Propeller Theory (Prandtlsche Tragflächen- und Propeller-Theorie). E. Trefftz. Zeit für angewandte Mathematik u. Mechanik, vol. 1, no. 3, June 1921, pp. 206-218, 13 figs. Fundamental principles of theory. Deals with aerofoils which, with given lift, have minimum drag. Calculation of lift and drag of given aerofoils. Screw propellers with minimum loss of energy.

AIRPLANES

Aerofoils. The Minimum Induced Drag of Aerofoils, Max. M. Munk. Nat. Advisory Committee for Aeronautics, Report No. 121, 1921, 18 pp. Mathematical discussion covering the lifting straight line, parallel lifting elements lying in a transverse plane, three-dimensional parallel lifting elements, lifting elements arranged in any direction in a transverse plane, etc.

De Havilland 32 Biplane. The D.H. 32 Commercial Biplane. Flight, vol. 13, no. 38, Sept. 22, 1921, pp. 629-630, 1 fig. Built by De Havilland Aircraft Co. 360 hp. Rolls-Royce engine.

De Havilland 29 Monoplane. The D.H. 29 Monoplane. Flight, vol. 13, no. 39, Sept. 29, 1921, pp. 641-647, 25 figs. Built at Stag Lane works by De Havilland Aircraft Co. 450 hp. Napier Lion engine. Internally braced wings.

Monoplanes vs. Biplanes. Monoplanes or Biplanes? A. Herbemont. Aviation, vol. 11, no. 15, Oct. 10, 1921, pp. 420-422, 3 figs. Compares several well-known European cabin machines, expressing commercial efficiency as pounds of pay load per horsepower. Translated from L'Air.

Pilotless. Pilotless Airplanes (L'avion sans pilote). A. Volmerange. Aeronautique, vol. 3, no. 28, Sept. 1921, pp. 345-351, 5 figs. Discusses automatic stability, the Sperry stabilizer, principle of distance-control, starting and landing.

[See also PARACHUTES.]

AIRSHIPS

Rubberized Fabric. Balloons, Airships and Rubberized Fabric, C. P. Burgess. India Rubber World, Vol. 65, no. 1, Oct. 1, 1921, pp. 3-6, 6 figs. Discusses principal characteristics of some typical airships and balloons, achievements of rubberized fabrics, etc.

Zeppelin. The Drag of Zeppelin Airships, Max M. Munk. Nat. Advisory Committee for Aeronautics, Report No. 117, 1921, 11 pp., 10 figs. Results of tests in which the propellers were stopped as quickly as possible while airship was in full flight.

ALLOY STEELS

Carbon and. Carbon and Alloy Steels: Their Selection and Use. P. W. Peel. Practical Engr., vol. 64, no. 1803, Sept. 15, 1921, p. 167.

Hardening. The Hardening of Tool Steel, S. N. Brayshaw. Eng. Production, vol. 3, no. 57, Nov. 3, 1921, p. 415. Results of work carried out by means of test bars and test cutters for purpose of determining effect of various annealings or heat treatments. (Abstract). Paper read before Sheffield Assn. Metallurgists & Metallurgical Chemists.

High-Resistance. Non-Magnetic, Flame-, Acid- and Rust-Resisting Steel. Chem. & Met. Eng., vol. 25, no. 17, Oct. 26, 1921, pp. 797-799, 5 figs. New high alloy steels developed in research laboratory of Crucible Steel Co. which can easily be worked and machined, but after heat-treatment become hard and resistant to attack of all agencies.

Tests. Elasticity and Strength of Special Steels at High Temperatures (Elastizität und Festigkeit von Spezialstahlen bei hohen Temperaturen). Georg Welter. Forschungsarbeiten auf dem Gebiete des Ingenieurwesens, no. 230, 1921, 65 pp., 99 figs. Results of tests carried out on special steels such as are commonly used in construction of steam turbines and engines, and gas, oil, automobile and airplane engines, to determine limit of elasticity at which permanent dilatation of steel begins. Describes apparatus used for tests.

ALLOYS

See BEARING METALS; COPPER ALLOYS; NICKEL ALLOYS; ZINC ALLOYS.

ALUMINUM

Annealing, Effect of. Unusual Grain Growth Due to Critical Strain. A. P. Knight. Chem. & Met. Eng., vol. 25, no. 18, Nov. 2, 1921, pp. 829-830, 7 figs. Discusses annealing of aluminum coffee pots, bottom of which was rough while sides were smooth.

Properties and Alloys. Aluminum, Its Production, Properties and Alloys (L'Aluminium, sa fabrication, ses proprietes, ses alliages). Léon Guillet. Révue de Metallurgie, vol. 18, no. 8, August 1921, pp. 461-526, 70 figs. Report of lecture at recent aluminum exposition. Appendixes giving curves for binary alloys. Bibliography.

ALUMINUM ALLOYS

Automobile Construction. Use of Wrought Aluminum Alloys in Automobile Construction, Walter Rosenhain. Automotive Industries, vol. 45, no. 18, Nov. 3, 1921, pp. 862-864. Discusses advantages and possible applications, piston difficulties, corrosion.

Bronzes. Notes on Casting Aluminum Bronze, Austin D. Wilson. Foundry, vol. 49, no. 20, Oct. 15, 1921, pp. 801-804, 27 figs. Micrographs illustrate effects of different compositions and heat treatments on structure. Presence of manganese tends to refine grain.

Castings, Cracks in. Cracks in Aluminum-alloy Castings, Robert J. Anderson. Trans. Am. Inst. Min. & Metallurgical Engrs., no. 1104-N, Oct. 1921, 22 pp.; also (in abstract), Min. & Metallurgy, no. 178, Oct. 1921, pp. 43-44. Effects of various factors on cracking; method of molding; prevention of cracks.

[See also ALUMINUM, Properties and Alloys.]

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NOTE.—The abbreviations used in indexing are as follows:

Academy (Acad.)
American (Am.)
Associated (Assoc.)
Association (Assn.)
Bulletin (Bul.)
Bureau (Bur.)
Canadian (Can.)
Chemical or Chemistry (Chem.)
Electrical or Electric (Elec.)
Electrician (Elecn.)
Engineer[s] (Engr.[s])
Engineering (Eng.)
Gazette (Gaz.)
General (Gen.)
Geological (Geol.)
Heating (Heat.)
Industrial (Indus.)
Institute (Inst.)
Institution (Instn.)
International (Int.)
Journal (Jl.)
London (Lond.)
Machinery (Machy.)
Machinist (Mach.)
Magazine (Mag.)
Marine (Mar.)
Materials (Matls.)
Mechanical (Mech.)
Metallurgical (Met.)
Mining (Min.)
Municipal (Mun.)
National (Nat.)
New England (N. E.)
Proceedings (Proc.)
Record (Rec.)
Refrigerating (Refrig.)
Review (Rev.)
Railway (Ry.)
Scientific or Science (Sci.)
Society (Soc.)
State names (Ill., Minn., etc.)
Supplement (Supp.)
Transactions (Trans.)
United States (U.S.)
Ventilating (Vent.)
Western (West)

ANEMOMETERS

Testing. Measurement of Air Velocities and the Testing of Anemometers, James Cooper. Iron & Coal Trades Rev., vol. 103, no. 2798, Oct. 14, 1921, p. 540. Discusses results obtained with a testing anemometer table based on that designed by H. Briggs many years ago and which is claimed to work perfectly.

ASH HANDLING

Conveyor. A New Ash Handling Conveyor. Eng. & Indus. Management, vol. 6, no. 16, Oct. 20, 1921, pp. 449–450, 4 figs. Describes system developed by Underfeed Stoker Co., Ltd., London.

AUTOMOBILE ENGINES

Cylinders. How Ford Cylinder Blocks are Cast, Pat Dwyer. Foundry, vol. 49, no. 19, Oct. 1, 1921, pp. 751–758, 7 figs. New River Rouge plant operated on continuous production principle; to make castings for 8,000 cars per day. Description of making cores, molds, pouring castings, melting equipment, etc.

Eight-Cylinder. Engines with Eight Cylinders in Line (Le Moteur a huit cylindres en ligne), A. Contet. La Vie Automobile, vol. 17, no. 738, Sept. 25, 1921, pp. 335–339, 12 figs. Discusses variations of eight-cylinder crankshafts and describes Panhard, Fraschini and other eight-cylinder engines.

Light-Metal. Recent Experiences with Light Metals in High-Speed Engines (Neue Erfahrungen mit Leichtmetallen in schnellaufenden Motoren), H. v. Selve. Zeit. für Metallkunde, vol. 13, no. 10, July 1921, pp. 316–318, 7 figs. Based on tests and experiences, writer strongly recommends increased use of aluminum and magnesium alloys in automobile construction and gives comparative data on weight, strength and expansion of aluminum castings and aluminum sheet pistons and magnesium pistons, as well as of connecting rods of steel and magnesium.

Rotary-Valve. A New Rotary Valve Engine. Automotive Industries, vol. 45, no. 22, Dec. 1, 1921, pp. 1065–1066, 3 figs. Chief advantage claimed is that of absolutely silent operation. Absence of valves and tappet rods at side of cylinder block allows location of accessories close to cylinders and a consequent narrow engine.

[See also CARBURETORS; CLUTCHES; CRANKCASES.]

AUTOMOBILE FUELS

Coke. Coke As a Fuel for Commercial Vehicles, Thomas Clarkson. Engineering, vol. 112, no. 2912, Oct. 21, 1921, pp. 579–580. Points out that when coke is used as motor fuel, either for raising steam or making gas, cost of transport may be very considerably reduced as compared with gasoline motor. Paper read before Instn. Automobile Engrs.

Condensation Temperatures. Condensation Temperatures of Gasoline- and Kerosene-Air Mixtures, Robert E. Wilson and D. P. Barnard. Jl. Indus. & Eng. Chem., vol. 13, no. 10, Oct. 1921, pp. 906–912, 12 figs. Describes a simple and reliable method for determining initial condensation temperature of fuels from air-fuel mixtures, an approximate method for determining temperatures of partial condensation in air-fuel mixtures, etc.

Kerosene. The Use of Kerosene in Automobile Engines (L'Emploi des pétroles lampants dans les moteurs d'automobiles), A. Grebel. Memoirs et Compte Rendu des Travaux de la Société des Ingenieurs Civils de France, vol. 74, no. 4–5–6, April-June 1921, pp. 250–269. Holds that it is not so much a question of carburization and carburetors, but of the engines, cycles, and manner of regulation. Tables of liquid fuels and their properties.

Total Heat Content. The Total Sensible Heats of Motor Fuels and Their Mixtures with Air, Robert E. Wilson and D. P. Barnard. Jl. Indus. & Eng. Chem., vol. 13, no. 10, Oct. 1921, pp. 912–915, 5 figs. Describes approximate methods in determining the total sensible heat content of Socony motor gasoline and kerosene and their mixtures with air at temperatures up to 500 deg. cent.

AUTOMOBILES

Camshafts. Manufacture of Accurate Camshafts, Edward K. Hammond. Machy. (N. Y.), vol. 28, no. 3, Nov. 1921, pp. 175–180, 8 figs. partly on p. 181. Describes important operations, and gives complete tabulated data on manufacturing procedure in making camshafts in Lincoln Motor Co.'s plant.

Declutcher, Automatic. Automatic Declutcher Introduced at Paris Show. Automotive Industries, vol. 45, no. 19, Nov. 10, 1921, p. 922, 3 figs. Gear shifting accomplished by taking foot off accelerator pedal and waiting until engine slows down to point where it is sure to be uncoupled by new device. Gear lever is then shifted without disengaging friction clutch.

Delage. A New 11 Hp. Delage. Autocar, vol. 47, no. 1353, Sept. 24, 1921, pp. 533–535, 7 figs. Four cylinder monobloc, 72 × 130 mm.; electric lighting and starting; four-speed gear; four-wheel braking system.

Duesenberg. New Duesenberg Reflects Experience Gained with Racing Cars, J. Edward Schipper. Automotive Industries, vol. 45, no. 18, Nov. 3, 1921, pp. 854–857, 5 figs. Equipped with eight-in-line engine, four-wheel brakes, overhead camshaft, and tubular connecting rods; high-pressure oiling, semi-elliptical springs.

Electric, Suspension. Eliminating Vibrations and Shocks in Electric Motor Vehicles (Come eliminare i danni delle vibrazioni e degli urt nei veicoli automotori elettrici), Gino Turrinelli. L'Elettrotecnica, vol. 8, no. 26, Sept. 25, 1921, pp. 581–584, 11 figs. Discusses methods of suspension and describes new system of suspension.

Fiat. The 10 Hp. Fiat (La 10 Hp. Fiat), A. Contet. La Vie Automobile, vol. 17, no. 737, Sept. 10, 1921, pp. 307–311, 15 figs. Discusses chassis, engines (four- and six-cylinder monobloc), speed control, etc.

Gear Release. Automatic Gear-Release (L'Auto-débrayage T. L.), G. Lienhard. La Vie Automobile, vol. 17, no. 738, Sept. 25, 1921, pp. 354–358, 12 figs. Describes the T. L. device, consisting of a wheel with a helicoidal rim, similar to the free wheel of bicyles, placed between engine and transmission gear.

German. New German Car Has Novel Design Features, Benno R. Dierfeld. Automotive Industries, vol. 45, no. 15, Oct. 13, 1921, pp. 703–706, 5 figs. Clutch design of this 30-hp. Protos is entirely new; unusual method of locking gears in position; cylinder block is excellent example of German engineering and foundry practice; no control hand levers on steering wheel; four-cylinder engine used.

Haynes. Longer Wheelbase and Larger Engine in New Haynes, J. Edward Schipper. Automotive Industries, vol. 45, no. 16, Oct. 20, 1921, pp. 764–766, 6 figs. New model "75" has 132-in. wheelbase and 299-cu. in. engine with block-cast cylinders, inclined valves, chain distribution, three-piece separate head, aluminum crankcase and hollow-shaft lubrication.

Improvements. Improvements in Automobile Manufacture (Neue Wege im Automobilbau), Otto Schwager. Motorwagen, vol. 24, nos. 26 and 27, Sept. 20 and 30, 1921, pp. 565–566 and 579–591, 15 figs. New Rumpler car with drop-pearl-shaped (streamline) frame and body based on experiences in airplane construction. The gearless Maybach car. The Atlantic two-seated cycle car.

Mack A B Chassis. Mack Chassis Now Adapted for Use as Rail Cars, Herbert Chase. Automotive Industries, vol. 45, no. 19, Nov. 10, 1921, pp. 918–921, 6 figs. Vehicles used for railway work have special axles, wheels and reverse gears, but most other parts of the chassis are identical with those used in standard Mack trucks. Special bodies seat from 25 to 35 passengers.

Pierce-Arrow Repair Service. Automotive Service Methods and Equipment Howard Campbell. Am. Mach., vol. 55, no. 20, Nov. 17, 1921, pp. 789–791, 7 figs. Tools used in remachining Pierce-Arrow transportation units. Reboring fixtures. Valve-spring tester. Welding and remilling axle shafts.

Renault 40-Hp. Testing a 40-Hp. Renault Automobile (Essai d'une Voiture Renault 40 chevaux), H. Petit. La Vie Automobile, vol. 17, no. 738, Sept. 25, 1921, pp. 340–346, 16 figs. Test data and description of engine (6-cylinder), transmission gear, chassis, etc.

Rumpler. A German Passenger Car of Radical Design. Automotive Industries, vol. 45, no. 17, Oct. 27, 1921, pp. 812–816, 12 figs. Describes Rumpler streamline car. Engine is aft and every possible obstacle on streamline body is removed to minimize air resistance.

Rumpler's New Automobile (Der neue Kraftwagen von Dr. Ing. Rumpler), A. Heller. Zeit. des Vereines deutscher Ingenieure, vol. 65, no. 39, Sept. 24, 1921, pp. 1011–1015, 11 figs. Special feature is its rear-axle drive with which only the compensating shafts oscillate and all joints are eliminated. Due to location of entire drive in rear a favorable form could be developed with regard to air resistance.

Stevens-Duryea Stevens-Duryea Producing High Grade Six, Herbert Chase. Automotive Industries, vol. 45, no. 22, Dec. 1, 1921, pp. 1061–1064, 7 figs. Describes changes made in chassis and Model E power plant, and gives details of construction.

Sunbeam 4-Seater. A New 2-Litre Sunbeam. Autocar, vol. 47, no. 1355, Oct. 8, 1921, pp. 624–627, 13 figs. Four-seater, 14-hp., four-cylinder 72 × 120 mm., overhead valves, aluminum cylinder blocks.

Suspension. The Suspension of Vehicles (Remarques sur la suspension des véhicules), P. Lemaire. La Technique Moderne, vol. 13, no. 1, Jan. 1921, pp. 7–11, 2 figs. Discusses transmission of shocks by wheels, comfortable and uncomfortable speeds, elastic constants of springs.

See also Electric, Suspension.

Wills Sainte Claire. Wills Sainte Claire Car Has Engine of Original Design, J. Edward Schipper. Automotive Industries, vol. 45, no. 19, Nov. 10, 1921, pp. 912–917, 8 figs. Eight-cylinder solid-head engine, overhead camshaft drive. Describes cooling system, oil circuit, etc. Gives specifications. 65 b.hp. at 2700 r.p.m. maximum.

Wolseley 7-Hp. A New 7-Hp. Wolseley. Autocar, vol. 47, no. 1353, Sept. 24, 1921, pp. 541–543, 9 figs. Water-cooled horizontally opposed twin, 82 × 92 mm. three-speed and reverse gear.

AVIATION

Air Harbors. Canadian Airharbors. Aviation, vol. 11, nos. 16 and 17, Oct. 17 and 24, 1921, pp. 448–450 and 481–482, 1 fig. Detailed description of each; markings for air harbors; the part of Canadian Air Regulations which provides for licensing of air harbors.

B

BALLOONS

Captive, Winding Machinery for. Winches for Captive Balloons (Les treuils de ballon captif), Léon Chollet. L'Aeronautique, vol. 3, nos. 27 and 28, August and Sept. 1921, pp. 316–319 and 377–380, 6 figs. Aug.: Describes various cars or trucks driven by steam or gasoline. Sept.: Discusses power of engine, speed of bringing down the balloon, winding cable, etc.

BEAMS

Continuous. Calculations for Continuous Beams with Third-Point Loading, Ewart S. Andrews. Concrete & Constructional Eng., vol. 16, no. 10, Oct. 1921, pp. 647–654, 5 figs. Deals with beams continuous over three spans.

Maximum Bending-moment Diagrams for Continuous Beams, C. S. Gray. Mech. World, vol. 70, no. 1813, Sept. 30, 1921, pp. 266–267, 7 figs. Discusses Clapeyron's theorem of three moments.

Curved. Bending Lines of Curved Beams (Biegungslinien ringförmiger Träger), Friedrich Düsterbehn. Eisenbau, vol. 12, no. 10, Oct. 11, 1921, pp. 249–264, 7 figs. Bending lines are developed for deformation of curved beams.

Sections. The Graphics of Beam and Girder Sections. Alan Pollard. Machinery (Lond.), vol. 19, no. 473, Oct. 20, 1921, pp. 63–66, 4 figs. Method for determining the centroid, moment of inertia, swing radius, and moduli for any shape of section on drawing board.

BEARING METALS

Properties. What Metals Serve Best in Bearings? Bruno Simmersbach. Raw Material, vol. 4, no. 9, Sept. 1921, pp. 316–320. Relation between physical-chemical properties of bearing alloys and their ability to live under strenuous duty. From Chemiker Zeitung.

BEARINGS, BALL

Roller and. Anti-Friction Bearings in the Steel Mill, A. M. MacCutcheon. Blast Furnace & Steel Plant, vol. 9, no. 10, Oct. 1921, pp. 600–607, 13 figs. Discusses ball and roller bearings, their manufacture, mounting and selection. Advantages and disadvantages of anti-friction bearings. (Abstract.) Paper read before Iron & Steel Elec. Engrs.

BEARINGS, ROLLER

Tangential Load. Experiments with Roller Bearings Under Tangential Load (Undersökningar rörande rullning under tangentialkraft), Arvid Palmgren. Teknisk Tidskrift (Mekanik), vol. 51, no. 9, Sept. 14, 1921, pp. 129–132, 8 figs. Discusses results of tests made in the S. K. F. laboratory.

BELTING

Cellulose. Tests with Cellulose Driving Belts (Versuche mit Zellstofftreibriemen), H. Rudeloff. Zeit. des Vereines deutscher Ingenieure, vol. 65, no. 40, Oct. 1, 1921, pp. 1041–1044, 4 figs. Account of tests to determine strength of paper composed of equal parts of soda and sulphite cellulose in the different stages of manufacture, for purpose of ascertaining degree to which strength of cellulose employed in yarns, textures and belts is utilized.

Rubber. Getting the Maximum Service in Rubber Transmission Belting, James B. McPherson. Chem. & Eng. News, vol. 33, no. 10, Oct. 1921, pp. 29–30. Writer advises securing maximum coefficient of friction, maximum arc of contact practicable, avoiding excessive tension, reckless use of dressings, and careless fastenings.

BLAST-FURNACE GAS

Steam Power from. Steam Power from Blast-Furnace Gas, Gordon Fox and F. H. Willcox. Power, vol. 54, no. 20, Nov. 15, 1921, pp. 706–709, 3 figs. Résumé on utilization of blast-furnace gas for steam making and development in burning gas alone or in combination with other fuels. Typical data are given as to amount of gas available and variation in supply. Importance of cleaning gas is emphasized, numerous recent installations are cited and developments in design summarized.

BLAST FURNACES

High Top Heat. Causes of High Top Heat in the Blast Furnace, Wallace G. Imhoff. Chem. & Met. Eng., vol. 25, no. 16, Oct. 19, 1921, pp. 737–740. Charts recording temperature of waste gases are of value in controlling furnace operations, indicating especially clearly exact time when charging is done and if charge is alternately hanging and slipping.

Pennsylvania. New Blast Furnace of the Crane Iron Works Modernizes Plant at Catasauqua, Pa., Richard Peters, Jr. Blast Furnace & Steel Plant, vol. 9, no. 10, Oct. 1921, pp. 577–580, 4 figs. Details of improvements in new blast furnace.

600-Ton. New 600-Ton Blast Furnace Plant. Blast Furnace & Steel Plant, vol. 9, no. 10, Oct. 1921, pp. 588–597, 11 figs. Trumbull-Cliffs Furnace Company new plant at Warren, Ohio, now completed. Many interesting features constructed in this plant. Record time made on construction work.

BLOWERS

Propeller Type. Propeller Blowers for Forced-Draft Furnaces (Propellergebläse für Unterwindfeuerungen), Werner Müller. Zeit. für Dampfkessel u. Maschinenbetrieb, vol. 44, no. 36, Sept. 9, 1921, pp. 281–284, 12 figs. Details of the Föge propeller blower based on design of airplane propellers. Discusses shape of propeller and housing, speed, power consumption and efficiency. Installation in forced-draft furnaces.

BOILER FEEDWATER

Concentration, Control of. Priming and Control of Boiler Water Concentration, Geo. C. Cook. Power Plant Eng., vol. 25, no. 20, Oct. 15, 1921, pp. 986–988. Discusses limit of impurities in feed-water and methods of controlling degree of concentration.

BOILER FIRING

Fuel Saving in. Fuel Saving in Relation to Capital Necessary, Joseph Harrington. Mech. Eng., vol. 43,

no. 11, Nov. 1921, pp. 725–726, 2 figs. Investigation shows economy resulting from use of efficiency equipment. Concrete illustrations given in support of theory discussed. (Abstract.)

Refined Fuel. Practical Experiences in Boiler Firing with Refined Fuels (Praktische Erfahrungen im Dampfkesselbetrieb mit veredelten Brennstoffen), H. Morgner. Zeit. für Dampfkessel u. Maschinenbetrieb, vol. 44, no. 33, Aug. 19, 1921, pp. 257–259. Notes on use of pulverized coal, and mixtures of anthracite and lignite.

BOILER PLANTS

Efficient Operation. Boiler-Plant Efficiency, Victor J. Azbe. Mech. Eng., vol. 43, no. 11, Nov. 1921, pp. 722–724 and 726, 5 figs. Usual wastes in boiler plants are brought out by means of tables and curves of boiler performance compiled from large number of observations. Shows to what extent these wastes are preventable or can be made to balance each other, and recommends standard for boiler operation toward which designers and operators may aim. Requirements of ideal boiler installation are summarized.

Oil-Burning. High-Pressure Oil-Burning Installation. Power, vol. 54, no. 17, Oct. 25, 1921, pp. 622–624, 5 figs. Boiler plant of Fall River Electric Light Co. converted from coal to oil burning.

Wimbledon Electrical Works. The New Boiler House Plant at Wimbledon Electricity Works. Eng. & Indus. Management, vol. 6, no. 15, Oct. 13, 1921, pp. 402–403, 1 fig. Consists of two Spearing horizontal water-tube boilers, each having actual evaporative capacity of 25,000 lb. per hr. with overload capacity for 8 hr. of 25 per cent above full load. Details of drive and feed pump.

BOILERS

Design and Settings. Boiler Equipment at River Rouge Plant of the Ford Motor Company, George T. Ladd. Proc. Engineers' Soc. of Western Pa., vol. 37, no. 3, April 1921, pp. 115–148 and (discussion) 149–157, 17 figs. Discusses design of boilers and settings. Discussion of powdered coal equipment and superheater equipment by H. D. Savage and J. R. Le Vally, respectively.

Flanging Methods. Special Methods of Boiler Flanging, George A. Richardson. Boiler Maker, vol. 21, no. 10, Oct. 1921, pp. 281–283, 8 figs. Hand flanging and sectional presses used for irregular shapes in boiler and tank fabrication.

BOILERS, WATER-TUBE

Advantages. The Advantages of Water Tube Boilers, James Kemnal. Mar. Eng. of Can., vol. 11, no. 9, Sept. 1921, pp. 22–23. Describes various cases where cylindrical boilers were replaced by water tube boilers.

BONUS SYSTEMS

Practical Application. Practical Application of the Bonus System for Increased Production (Della practica applicazione del sistema del premio di maggior produzione nelle officine del materiale fisso di Pontassieve), Giorgio Lasz. Rivista Tecnica delle Ferrovie Italiane, vol. 22, no. 2, Aug. 15, 1921, pp. 66–70. Describes experience with Rowan piece work system at an Italian railroad shop.

BRAKES

Air, Westinghouse. New Tests of the Westinghouse Continuous Air Brake (Nouveaux essais du frein continu système "Westinghouse"), M. Tête. Revue Générale des Chemins de Fer et des Tramways, vol. 40, no. 7, July 1921, pp. 22–50, 8 figs. Results of tests in France by commission appointed by Minister of Public Works are entirely satisfactory.

Automotive Engine. Motor Brakes (Motorbremsen), C. Wirsum. Motorwagen, vol. 24, no. 27, Sept. 30, 1921, pp. 600–605, 12 figs. Investigations of the braking effect of automotive engines and recommendations for design. Results of tests with Saurer brakes.

BRASS FOUNDRIES

Cast Ingots. The Casting of Brass Ingots, R. Genders. Metal Industry (Lond.), vol. 19, no. 14, Sept. 30, 1921, pp. 261–262, 2 figs. Describes experiments carried out to minimize occurrence of non-metallic inclusions.

BRONZES

Antimony, Influence of. The Influence of Antimony in Bronze (Der Einfluss des Antimons im Rotguss), J. Czochralski. Zeit. für Metallkunde, vol. 13, no. 9, June 1921, pp. 276–281, 8 figs. Investigation of influence of antimony additions up to 3 per cent on mechanical properties of bronze with and without lead. It is shown that with antimony content up to 0.3 per cent with 5 per cent lead content the treatment and casting of bronze is favorably influenced.

Arsenic, Influence of. The Influence of Arsenic in Bronze (Der Einfluss des Arsens im Rotguss), J. Czochralski. Zeit. für Metallkunde, vol. 13, no. 11, Aug. 1921, pp. 380–383, 10 figs. Investigation of influence of additions of up to 2 per cent of arsenic on mechanical properties of bronze with and without lead. It is shown that with arsenic content of up to 3 per cent with 5 per cent lead content the casting of bronze is favorably influenced.

Cold-Drawing, Effect of. The Effect of Progressive Cold-Drawing Upon Some of the Physical Properties of Low-Tin Bronze, W. E. Alkins and W. Cartwright. Metal Industry (Lond.), vol. 19, no. 15, Oct. 7, 1921, pp. 280–285 and (discussion) p. 286, 7 figs. Gives results of experiments showing variation during cold-drawing of the three properties: tensile strength, specific volume and scleroscope hardness. Describes characteristics of individual curves. Paper read before Inst. of Metals.

C

CABLES, HOISTING

Metal. Metal Cables For Winding Engines (Les cables d'extraction metalliques ronds), M. Durnerin. Révue de l'Industrie Minérale, no. 18, Sept. 15, 1921, pp. 579–599, 5 figs. Discusses construction, choice of steels, effect of torsion, elasticity of cables and its parts, calculation of cross-sections, and describes a patented automatic "anti-torsion" which increases life of cable.

CAR LIGHTING

Gas and Electric. Railway Car Lighting, George E. Hulse. Trans. Illuminating Eng. Soc., vol. 16, no. 5, July 20, 1921, pp. 99–110 and (discussion) 110–116. Discusses gas and electric lighting, reflectors, and glassware.

CAR SHOPS

Equipment. Kanchrapara Carriage and Wagon Works, Eastern Bengal Railway. Ry. Gaz., vol. 35, no. 17, Oct. 21, 1921, pp. 598–600, 12 figs., partly on pp. 601–604. A scientifically designed layout, together with up-to-date machine, etc., equipment, combine to make Kanchrapara works of special interest.

CARS

Couplers. Measures for the Solution of the Coupling Problem for Main and Narrow-Gage Lines (Massnahmen zur Lösung der Kupplungsfrage für Haupt- und Kleinbahnen), H. Scharfenberg. Glasers Annalen, vol. 89, nos. 3 and 4, Aug. 1 and 15, 1921, pp. 27–32 and 37–42 and (discussion) pp. 42–44, 19 figs. Discusses development and different coupling systems. Address before German Mech. Eng. Soc.

Dining. Great Northern Train Service Between London and West Riding of Yorkshire. Ry. Gaz., vol. 35, no. 17, Oct. 21, 1921, pp. 607–610, 9 figs., partly on pp. 605–606. Describes new rolling stock built on twin bogie principle, with an articulated dining car train, embodying various improvements, including electric cooking.

Pressed Metal Parts. The Use of Pressed Parts in Car and Locomotive Construction (Die Verwendung von Pressteilen im Waggon- und Lokomotivbau), W. Loewe. Glasers Annalen, vol. 89, no. 3, Aug. 1, 1921, pp. 32–36, 12 figs. Describes production of pressed metal parts and suggests means of overcoming difficulties in connection with their adoption. Among their advantages over cast parts are mentioned, greater safety, elimination of use of copper, and adaptability to standardization.

CARS, PASSENGER

Design. On the Question of Passenger Carriages, E. Biard. Bulletin International Ry. Assn., vol. 3, no. 9, Sept. 1921, pp. 1205–1274. Discusses safety and comfort, types of construction and general design of carriages, component parts, chief devices and various accessories of underframe and body. Appendixes.

CARS, REFRIGERATOR

Milk Tanks, Use of. The Use of Car Tanks for Transporting Milk. Ry. Rev., vol. 79, no. 17, Oct. 22, 1921, pp. 543–544, 2 figs. Describes equipment of B. & O. R.R. for transporting milk in bulk in refrigerator cars fitted with glass-lined tanks.

CARBURETORS

Kerosene. Carburetors for Kerosene (Les Carburateurs a Pétrole), A. Mariage. Memoirs et Compte Rendu des Travaux de la Société des Ingenieurs Civils de France, vol. 74, no. 4–5–6, April-June 1921, pp. 279–290, 3 figs. Expresses the views of Compagnie Générale des Omnibus of Paris and gives results of their experiments.

CASTING

Centrifugal. Control of Centrifugal Casting by Calculation, Robert F. Wood. Mech. Eng., vol. 43, no. 11, Nov. 1921, pp. 727–728 and 730, 2 figs. Analyzes controlling factors, with view first of setting down definite mathematical relations between them, and secondly so expressing these relations as to make them useful both in design and operation of machines for casting. (Abstract.)

Melts Metal For Pipe in the Mold, E. C. Kreutzberg. Foundry, vol. 49, no. 19, Oct. 1, 1921, pp. 772–774, 6 figs. Centrifugal casting process developed by L. Cammen uses an electrically heated mold. Aluminum tubing made by this process which will be developed for casting steel.

CASTINGS

Molds, Plaster. Permanent Molds, Edward D. Gleason. Metal Industry (N. Y.), vol. 19, no. 10, Oct. 1921, pp. 391–393. Description of methods of making plaster molds for finished castings to eliminate machining operations.

Non-Ferrous. Producing Small Nonferrous Castings, Raymond H. Sullivan. Can. Foundryman, vol. 12, no. 10, Oct. 1921, pp. 30–32, 2 figs. Discusses daily production of a large number of small duplicate castings and method adopted. Paper read at Foundrymen's Convention.

CENTRAL STATIONS

Blackburn, England. New Electricity Generating Station at Blackburn. Engineer, vol. 132, no. 3434, Oct. 21, 1921, pp. 416–420, 8 figs. Station contains two turbo-alternators, each of 10,000 kw. capacity. Details of coal- and ash-handling plant; boiler plant; cooling towers; switchgear, transformers, etc.

Cotton Industry. Value of Central Station Service in the Cotton Industry, F. E. Sawyer and H. E. Duren. Nat. Elec. Light Assn. Bul., vol. 8, no. 10, Oct. 1921, pp. 586–590. Describes some mills that have changed from own power production to purchased power and its advantages.

CHAIN DRIVE

Silent. The Application and Manufacture of Silent Chain, J. Edward Schipper. Automotive Industries, vol. 45, no. 16, Oct. 20, 1921, pp. 773–778, 18 figs. Manufacture of chain parts, their assembly and inspection, is outlined.

CHROMIUM STEEL

Bibliography. A Bibliography and Abstract of Chromium Steels, F. P. Zimmerli. Chem. & Met. Eng., vol. 25, no. 18, Nov. 2, 1921, pp. 837–843. Chronological arrangement of some of the principal papers on chromium and chromium alloy steels published during the period 1798 to 1919, with brief summary of their scope.

CLUTCHES

Manufacture and Assembly. The Manufacture and Assembly of a Cork Insert Disk Clutch, J. Edward Schipper. Automotive Industries, vol. 45, no. 17, Oct. 27, 1921, pp. 823–826, 13 figs. Description of machining and assembly operations on Hudson and Essex clutches.

COAL HANDLING

Screening and Loading Installation. Screening and Loading Installation of the Boekit-Asem Anthracite Mine at Tandjoeng in Sumatra (Kolenzeefen laadinrichting voor de Boekit-Asem-steenkolenmignen te Tandjoeng op Sumatra), A. Guyot Van Der Ham. Ingenieur, vol. 36, no. 39, Sept. 24, 1921, pp. 772–774, 3 figs. Constructed by Baum Machine Works, Herne, Westfalia. Details of arrangement and equipment.

COKE

Uses. Production, Distribution, and Uses of Coke, E. W. L. Nicol. Gas Jl., vol. 156, no. 3047, Oct. 5, 1921, pp. 37–38. Discusses use of coke as fuel and adapting boiler furnaces to coke. See also Iron & Coal Trades Rev., vol. 103, no. 2796, Sept. 30, 1921, p. 471.

COMBUSTION

Equations. Combustion Equations (Die Gleichungen des Verbrennungsvorganges), R. Mollier. Zeit. des Vereines deutscher Ingenieure, vol. 65, no. 42, Oct. 15, 1921, pp. 1095–1096. The stoichiometrical ratios for incomplete combustion are developed.

High-Pressure. Gaseous Combustion at High Pressures—II, William Arthur Bone and William Arthur Haward. Proc. Roy. Soc., vol. 100, no. A 702, Oct. 4, 1921, pp. 67–84, 7 figs. Further experiments to determine a direct relation between the actual rate at which potential energy is transferred on explosion as sensible heat to its products and the magnitude of chemical affinity between its combining constituents.

Initial Temperatures. Initial Temperatures with Heated Combustion Air (Ueber Anfangstemperaturen mit erhitzter Verbrennungsluft), Otto H. Binder. Feuerungstechnik, vol. 9, no. 23, Sept. 1, 1921, pp. 219–220, 1 fig. Presents formula used by author for calculation of initial temperatures.

CONDENSERS, STEAM

New Type High-Efficiency. Steam-Condensing Plants, Paul A. Bancel. Mech. Eng., vol. 43, no. 11, Nov. 1921, pp. 711–716 and 758, 14 figs. Detailed consideration of fixed and operating charges in surface-condenser installations, and description of new type of high-efficiency condenser.

CONVEYORS

Pulverized Materials. Pulverized-Material Conveyor System. Power, vol. 54, no. 17, Oct. 25, 1921, pp. 628–629, 4 figs. Describes the Fuller-Kinyon conveying system for pulverized material, comprising a power-driven pump, function of which is to start the mass in motion; source of compressed-air supply and a pipe through which material flows.

Types. Mechanical Handling and Conveying of Materials, Richard P. Terry. Mech. World, vol. 70, nos. 1814 and 1815, Oct. 7 and 14, 1921, pp. 293–294 and 301–302. Oct. 7: Discusses bucket elevators and worm or Archimedean screw conveyors. Oct. 14: Discusses band, Zimmer, gravity and pneumatic conveyors. Paper read before Belfast Assn. of Engrs.

[See also ASH HANDLING, Conveyor.]

COOLING TOWERS

Investigation. Investigation of Chimney Cooling Towers (Die Beurteilung von Kaminkühlern), Kurt Neumann. Zeit. des Vereines deutscher Ingenieure, vol. 65, no. 41, Oct. 8, 1921, pp. 1070–1074, 3 figs. Thermodynamic investigation of phenomena occurring in chimney cooling towers. Equation is derived for determination of temperatures of the hot and recooled water dependent upon operating conditions. Gives results of tests on high-capacity cooling towers in industrial operation.

COPPER ALLOYS

Cupro-Nickel. Manufacture of Cupro-Nickel, Herbert D. Swift. Metal Industry (N. Y.), vol. 19, no. 10, Oct. 1921, pp. 394–395. Description of process going in regular order from casting to packing.

CORROSION

Electrolytic. Electrolytic Corrosion of Lead Thallium Alloys, Colin G. Fink and Charles H. Eldridge. Am. Electrochem. Soc., advance paper, no. 26, for meeting Sept. 29-Oct. 1, 1921, pp. 335–344, 4 figs. Shows that addition of thallium to lead alloys has been very effective in reducing anodic corrosion in acid copper sulphate electrolyte containing nitric and hydrochloric acids.

Heating System. Preventing Corrosion in Heating Systems, Perry West. Domestic Eng. (Chicago), vol. 97, no. 2, Oct. 8, 1921, pp. 50–53 and 82–84, 4 figs. Describes deoxidizing and de-aerating methods.

COST ACCOUNTING

Classification of Surplus. Classification of Surplus, C. B. Couchman. Jl. of Accountancy, vol. 32, no. 4, Oct. 1921, pp. 265–278. Discusses various kinds of surpluses and their display in the accounts. Paper read before Am. Inst. of Accounts.

Uniform Mill Systems. Uniform Mill Cost Systems, C. Oliver Wellington. Paper, vol. 29, no. 6, Oct. 12, 1921, pp. 13–15. Discusses advantages of uniformity in cost accounting.

COSTS

Material, Recording. The Recording of Material Costs, E. W. Workman. Eng. & Indus. Management, vol. 6, no. 16, Oct. 20, 1921, pp. 426–427. Describes method of dealing with material charges which has been found to work exceptionally well in large engineering firm using Hollerith system for dealing with its labor and overhead expenses.

CRANES

Bridge. New Type of Bridge Crane for Handling Sand and Gravel, W. A. Scott. Cem., Mill & Quarry, vol. 19, no. 8, Oct. 20, 1921, pp. 27–28, 2 figs. Has max. length of 184 ft.; clamshell bucket has capacity of 3 yd.; carriage speed, 800 ft. per min.; bucket speed, 200 ft.

Locomotive. Crane Operated on a Railroad Truck (Grue pivotante sur wagon a voie normale). Bulletin Technique de la Suisse Romande, vol. 47, no. 20, Oct. 1, 1921, pp. 229–234, 3 figs. Carrying capacity of cranes 10–12 tons, radius of action 6 m. Trucks are of special construction.

CRANKCASES

Malleable-Iron. Crank Cases Made of Malleable Iron. Foundry, vol. 49, no. 19, Oct. 1, 1921, pp. 762–766, 10 figs. An extensive series of experiments in molding and in subsequent heat treatment was required before castings were produced on a commercial basis.

CUTTING METALS

Universal Oxygen-Jet. A Universal Oxygen-Jet Cutting Machine. Eng. Production, vol. 3, no. 56, Oct. 27, 1921, pp. 395–397, 3 figs. Details and uses of machine by Godfrey Eng. Works, London.

D

DIES

Automobile Parts. Making Dies for Forming Automobile Parts, Richard Dale. Iron Age, vol. 108, no. 18, Nov. 3, 1921, pp. 1127–1129, 10 figs. Explains design and construction for manufacture of such articles as brake drums and step brackets.

Carburetor Bowl. Drawing Dies for Manufacturing a Carburetor Bowl, N. T. Thurston. Machy. (N. Y.), vol. 28, no. 3, Nov. 1921, pp. 218–221, 11 figs. Shows how substantial saving was effected by drawing and forming carburetor bowl on power presses. Describes successive operations.

Self-Opening Dieheads. Making the Coventry Self-Opening Diehead. Am. Mach., vol. 55, no. 17, Oct. 27, 1921, pp. 678–681, 15 figs. Materials tested in an up-to-date laboratory; parts inspected and sent to storeroom for reissue after each operation. Work carried out in self-contained factory at Edgwick, Coventry, England.

Shaving Tools. Notes on the Design of Shaving Tools, Hugo F. Pusep. Am. Mach., vol. 55, nos. 16 and 17, Oct. 20 and 27, 1921, pp. 624–626 and 686–689, 18 figs. Second operation necessary to obtain accuracy of size and contour. Discusses three general classes of shaving tools.

Wire-Drawing, Diamond. Diamond Dies for Wire Drawing, C. W. Busick. Am. Mach., vol. 55, no. 18, Nov. 3, 1921, pp. 703–705, 7 figs. How dies are lapped and tested for size. Automatic lapping machines for this work.

DIESEL ENGINES

Combustion in. Explosion and Internal-Combustion Engines (Moteurs a Explosion et a Combustion Interne), F. Huard. Arts et Métiers, vol. 74, no. 11, August 1921, pp. 242–246, 2 figs. Discusses combustion in Diesel and semi-Diesel engines. (Concluded.)

Marine. A New Nelseco Diesel Engine. Motorship, vol. 6, no. 10, Oct. 1921, pp. 798–801, 10 figs. Details of 600-b.hp. marine Diesel engine designed for electric and direct drives, built by New London Ship & Engine Co., Groton, Conn. Fuel consumption at 25 per cent overload is 0.42 lb. per b.hp.

Building Marine Diesel Engines. Eng. Production, vol. 3, nos. 53 and 54, Oct. 6 and 13, 1921, pp. 321–325 and 349–352, 21 figs. Methods and equipment of the North British Diesel Engine Works, Ltd., at Glasgow, founded in 1913 for purpose of developing marine Diesel engine up to 12,000 hp.

The Marine Diesel Engine: Its Reliability in Service, Andrew J. Brown. Trans. Inst. Mar. Engrs., vol. 33, Sept. 1921, pp. 279–307 and (discussion) 307–325, 7 figs. Discusses the various parts of engine from the standpoint of showing how reliability is ensured.

Worthington Solid-Injection. The Worthington Solid-Injection Diesel. Power, vol. 54, no. 18, Nov. 1, 1921, pp. 675–677, 3 figs. Engine operating on Diesel cycle without air injection. Novel means employed to secure combustion at constant pressure with pump feed.

DROP FORGING

Modern Practice. Modern Drop-forging Practice, Fred R. Daniels. Machy. (N. Y.), vol. 28, no. 3, Nov. 1921, pp. 213–217, 8 figs. Comparison of drop forgings and castings, and general methods of making them.

DYNAMOMETERS

British Traction. A New British Traction Dynamometer. Automotive Industries, vol. 45, no. 18, Nov. 3, 1921, pp. 860–861, 3 figs. Description of recording instrument designed especially for use in tractor trials; registers drawbar pull, time, and distance covered.

E

ELECTRIC DRIVE

Fabric Printing Machines. Electric Drive for Fabric Printing Machines (Commande électrique des machines a imprimer les tissus), Louis Grosheintz. La Technique Moderne, vol. 13, no. 2, Feb. 1921, pp. 71–74, 4 figs. Shows that d.c. drive is most suitable.

Lumber Mills. Application of Electrical Energy in Lumber Mills, W. A. Scott. Elec. Rev. (Chicago), vol. 79, no. 19, Nov. 5, 1921, pp. 685–688, 6 figs. Saws, conveyors and other units driven by belted and direct-connected motors; special requirements peculiar to lumber industry; mill refuse as fuel to generate electric power.

ELECTRIC FURNACES

Gray-Iron Castings. Gray Iron Castings from Electric Furnaces, Thomas Robson Hay. Iron Age, vol. 108, no. 19, Nov. 10, 1921, pp. 1214–1215. Present electric practice and advantages over older method. Comparative cost.

Induction. A New Electric Induction Furnace (Nouveau four électrique a induction), H. Vigneron. La Nature, no. 2475, Sept. 10, 1921, pp. 163–165, 5 figs. Describes Northrup system and its applications.

Iron Industry. Electric Furnace Possibilities in the Western Iron Industry, R. C. Gosrow. Jl. Electricity & Western Industry, vol. 47, no. 7, Oct. 1, 1921, pp. 265–266. Analysis of opportunities open to the electric furnace in the Western iron industry, with data on costs.

Repelling-Arc Type. Something New in Electric Furnaces, E. F. Cone. Sci. Am., vol. 125, no. 14, Oct. 1, 1921, p. 229, 1 fig. Describes repelling-arc type of furnace having a self-regulating, flaming arc torch.

Superheating Iron. Superheating Iron Electrically, George K. Elliott. Iron Trade Rev., vol. 69, no. 16, Oct. 20, 1921, pp. 1007–1011. States that by using basic-lined electric furnace in conjunction with cupola, high-temperature iron can be produced, desulphurization can be accomplished easily and impurities closely controlled. Compares composition and strength. Paper presented under auspices of Am. Foundrymen's Assn. before Instn. British Foundrymen.

ELECTRIC LOCOMOTIVES

Characteristics. Characteristics of the Electric Locomotive, N. W. Storer. Jl. Franklin Inst., vol. 192, no. 4, Oct. 1921, pp. 453–467, 8 figs. Deals with d.c. and a.c. locomotives, and regenerative braking.

Comparison with Steam. Some Mechanical Characteristics of High-Speed, High-Power Locomotives, A. W. Gibbs. Jl. Franklin Inst., vol. 192, no. 4, Oct. 1921, pp. 469–495, 26 figs. Deals principally with results of comparative trial of steam and electric locomotives made in 1907 to secure information in connection with design of electric locomotives for Pennsylvania terminal in New York.

Control Equipment. Electrical Considerations Which Govern in a Choice of Locomotives for Any Given Class of Service, H. H. Johnston. Coal Age, vol. 20, no. 18, Nov. 3, 1921, pp. 717–719, 4 figs. Locomotives with dynamic-braking controllers deliver current on descending grades and must have additional motor capacity. Series-and-parallel control vs. series-parallel control.

German. New Electric Passenger-Train Locomotives for the Silesian Mountain Railway (Neue elektrische Personenzug-Lokomotiven für die Schlesischen Gebirgsbahnen), H. Loewentraut. Elektrische Kraftbetriebe u. Bahnen, vol. 19, no. 17, Sept. 10, 1921, pp. 201–203, 2 figs. Specifications: Gage, 1435 mm.; driving-wheel diam., 1250 mm.; leading wheel diam., 1000 mm.; max. speed, 90 km. per hr.; contact line voltage, 15,000 volts; frequency, $16\frac{2}{3}$ periods.

Midi Railway, France. Mechanical Aspects of the New Electric Double-Bogie Locomotives of the Midi Railroad in France [Sur les dispositions mécaniques d'ensemble des nouvelles locomotives électriques a deux bogies moteurs (type de la compagnie des chemins de fer du Midi)], Fernand Broussouse. Le Technique Moderne, vol. 13, no. 3, March 1921, pp. 97–101, 12 figs. Discusses French and American suspensions, interchangeability and balancing of Midi bogies, etc.

Selection. Mechanical and Engineering Considerations Determining the Selection of an Electric Locomotive, H. H. Johnston. Coal Age, vol. 20, no. 17, Oct. 27, 1921, pp. 679–681, 5 figs. Discusses mine-haulage equipment and their specifications, locomotives, speed, and weight of rail.

ELECTRIC PLANTS

Bangor, Me. Remodeling Plant to Increase Rating, Phifer Smith. Elec. World, vol. 78, no. 17, Oct. 22, 1921, pp. 815–818, 5 figs. Describes new constructions at Veazie power plant of Bangor (Me.) Ry. & Electric Co., including four new units of 1,800 kw. capacity each.

Blackburn, England. Electricity Supply in Blackburn. Electrician, vol. 87, no. 2267, Oct. 28, 1921, pp. 536–539, 3 figs. Describes coal and ash handling plants, boiler house, turbo-alternators (two 10,000 kw. each driving 6,600-volt 50-period three-phase alternators), and auxiliaries of new power station.

Edinburgh. New Electricity Station at Edinburgh, S. B. Donkin. Electrician, vol. 87, no. 2263, Sept. 30, 1921, p. 407. Describes equipment, including generating plant, sea work pumps, shafts and tunnels. H. T. three-phase current; ultimate capacity 100,000 kw. (Abstract.) Paper read before British Assn.

England. Recent Extensions at Sunderland. Electrician, vol. 87, no. 2263, Sept. 30, 1921, pp. 414–415, 4 figs. Describes turbo-alternator, motor generators, busbar and switchboard construction of Corporation Generating Works.

Large Units. Some Notes on Large Electric Units, Stanley Parker Smith. Electrician, vol. 87, no. 2262, Sept. 23, 1921, pp. 378–380, 5 figs. Discusses prime movers, a.c. and d.c. production, converters, mercury rectifiers, etc. (Abstract.) Paper read before British Assn.

London Underground Railways. Chelsea Power Station—London Underground Railways. Tramway & Ry. World, vol. 50, no. 20, Oct. 20, 1921, pp. 185–189, 5 figs. Describes new equipment installed, including 15,000-kw. turbo-alternators, condensing water plant, etc.

Small. Economies in Operation of Small Power Plants, E. S. Hight. Elec. Rev. (Chicago), vol. 79, no. 16, Oct. 15, 1921, pp. 573–576, 3 figs. Discusses selection of coal, reduction of air leakage and radiation losses, engine room economies, etc. Extracts from paper before Iowa section of N.E.L.A.

Steel Works, Rumania. Operating Experiences with the Electric Plants of the Resita Steel Works (Rumania) (Einige Betriebserfahrungen mit den elektrischen Anlagen der Eisenwerke in Resita), Erick Beck. Elektrische Kraftbetriebe u. Bahnen, vol. 19, no. 19, Oct. 10, 1921, pp. 225–228, 2 figs. Current is supplied from three power plants; viz., one hydroelectric station, one blast-furnace-gas engine plant, and one 2500-kw. steam turbine, all supplying a single network with 5000-volt three-phase current with frequency of 20.8 periods.

ELECTRIC RAILWAYS

Italy. Valtellina Railway is Extended, E. Huldschiner. Elec. Ry. Jl., vol. 58, no. 19, Nov. 5, 1921, pp. 816–817, 1 fig. Discusses new trolley suspension and new locomotive; tests show satisfactory operation. Translated from Elektrotechnische Zeit.

Ore-Carrying, Chile. A Visit to the Tofo Mine of the Bethlehem Chile Iron Mines Co. (Una visita al mineral del Tofo de la Bethlehem Chile Iron Mines Co.), Ricardo Solar Puga. Anales del Instituto de Ingenieros de Chile, vol. 21, no. 6, June 1921, pp. 397–403, 8 figs. Describes first electric railroad in Chile used for ore carrying. Locomotives are of 1200 hp. d.c. 2400 volt.

Third-Rail System. Experiences of Northwestern Pacific Ry. with Third Rail System, C. E. Hatch. Eng. & Contracting, vol. 56, no. 16, Oct. 19, 1921, p. 380. Experiences in operation of 37 mi. of electrified track on which third-rail system is employed. Notes on how contact rail is supported; protections at crossings and stations; method of carrying feeders; and maintenance cost. (Abstract.) Paper read before Pac. Ry. Club.

ELECTRIC WELDING, ARC

Rail Joints. Arc Welded Rail Joints. Welding Engr., vol. 6, no. 10, Oct. 1921, pp. 27–32, 13 figs. Discusses welding rail joints by the Detroit street-car system and tests made.

ELEVATORS

Electrical Troubles. Locating Electrical Trouble on Elevators, William Zepernick. Power, vol. 54, no. 20, Nov. 15, 1921, pp. 755–757, 14 figs. Grounds, short circuits and open circuits defined. Methods of grounding power systems. Examples given on how to locate electrical faults on controller equipment.

EMPLOYEES

Thrift Encouragement by Employers. Thrift Encouragement by Employers—V, Leonhard Felix Fuld. Indus. Management, vol. 62, no. 5, Nov. 1921, pp. 287–289. Points out that investment companies appear to be ideal thrift encouragement plan for workers, as they furnish a thrift encouragement vehicle for each class of worker.

EMPLOYEES, TRAINING OF

Selection and. Industrial Training and Selection of Personnel, C. R. Dooley. Chem. & Met. Eng., vol. 25, no. 15, Oct. 12, 1921, pp. 692–695. Outline of basic principles underlying modern methods of selecting and training employees, and some helpful suggestions for solving personnel problems.

ENAMELING

Steel Containers. Enamel-Lined Apparatus, Chester H. Jones. Chem. & Met. Eng., vol. 25, no. 20, Nov. 16, 1921, pp. 927–932, 17 figs. Plant of Elyria Enameled Products Co. at Elyria, Ohio, engages in manufacture of enameled equipment for service in many varieties of plant processing; steel and cast-iron containers; burning equipment; composition and properties of enamels; control and management of operations.

EVAPORATORS

Design. An Improvement in Evaporator Design, Robert V. Cook. Chem. Age (N. Y.), vol. 29, no. 10.

Oct. 1921, pp. 409–410, 1 fig. Describes the criss-cross evaporator.

Tests. Result of Operations With Some Evaporators (Résultats de marche de quelques appareils d'evaporation), M. Depasse. Bul. de l'Association des Chimistes de Sucrerie et de Distillerie, vol. 38, no. 10, April 1921, pp. 383–404 and (discussion) 407–409, 2 figs. Gives test data with two-stage, three-stage, and four-stage evaporators.

F

FACTORIES

Hosiery. Up-to-the-Minute Design for New Hosiery Factory, H. P. Elliott. Contract Rec., vol. 35, no. 45, Nov. 9, 1921, pp. 965–967. Plant of Holeproof Hosiery Co. of Canada, Ltd., London, Ont., is said to combine every feature that will make employees comfortable and efficient. Details of heating and ventilating, boiler house, hot-water supply, water-softening plant, illuminating system, power transmission, telephone, electric time clocks, etc.

Planning Operations. Notes on the Preparation of Work Lay Outs, H. Varley. Eng. & Indus. Management, vol. 3, no. 57, Nov. 3, 1921, pp. 491–494, 9 figs. Writer enumerates points which should be carefully considered when a part is to be laid out in operations.

Rubber Tires. Mechanical Features of Tire Factory. Iron Age, vol. 108, no. 20, Nov. 17, 1921, pp. 1259–1265, 8 figs. New Kelly-Springfield plant is said to have unusually complete interconnection of mechanical services. Notes on tunnels, piping, wiring and communication.

FACTORY MANAGEMENT

See INDUSTRIAL MANAGEMENT.

FANS, CENTRIFUGAL

Design. Controlling Factors in Fan Design, David Darrin. Heat. & Vent. Mag., vol. 18, no. 10, Oct. 1921, pp. 49–52. Discusses required capacities, available space and attendance, allowable first cost and operating cost, etc., and gives table of present standards of fan design.

Electrically Driven. Electrically Driven Centrifugal Fans for Mine Ventilation. Mech. World, vol. 70, no. 1815, Oct. 14, 1921, pp. 303–304. Discusses characteristics of fans and motors, power requirements, etc.

Heaters and. Fans and Heaters, Charles L. Hubbard. Southern Engr., vol. 36, no. 2, Oct. 1921, pp. 44–49, 12 figs. Working data for fans; fan drives; heaters; determining size of heater; heater arrangements; heater connections, ducts and flues.

FATIGUE

Industrial. Physiological Methods for Measuring Industrial Fatigue (Les Methodes Physiologiques actuelles d'evaluation de la Fatigue dite "Industrielle"), D. Glibert. Annales des Mines de Belgique, vol. 22, no. 3, 1921, pp. 837–847, 1 fig. Concludes that present methods are not strictly applicable.

Reduction. Reducing Fatigue in Tool Rooms, F. B. and L. M. Gilbreth. Iron Trade Rev., vol. 69, no. 16, Oct. 20, 1921, pp. 1004–1006, 7 figs. Orderly arrangement of tools, conveniently placed shelves and drawers, and white surfaces tend to improve conditions in tool crib. Ample sunlight important. (Abstract.) Paper before Soc. Indus. Engrs.

Tests. Fatigue Tests at Purdue University, George H. Shepard. Indus. Management, vol. 62, no. 5, Nov. 1921, pp. 281–286, 4 figs. How exertion and rest periods affect efficiency. Includes chart showing output in foot-pounds under certain conditions of work and rest periods.

FILING SYSTEM

Classification, Indexing and. Classification, Filing and Indexing System for Pulp and Paper Library, Carleton E. Curran. Paper, vol. 28, nos. 19, 20 and 21, July 13, 20 and 27, 1921, pp. 9–11, 23 and 30, pp. 17–19 and pp. 17–18. Gives an adaptation of the Dewey classification.

FLIGHT

Soaring. Soaring Flight, L. Prandtl. Aviation, vol. 11, no. 16, Oct. 17, 1921, p. 459, 1 fig. Discusses soaring of birds and possibilities of human soaring flight. Translated from Zeitschrift für Flugtechnik und Motorluftschiffahrt, July 30, 1921.

Some Remarks Concerning Soaring Flight, L. Prandtl. Flight, vol. 13, no. 38, Sept. 22, 1921, pp. 633–634. Utilization of wind power in gliding planes. Translated from Zeitscrift für Flugtechnick und Motorluftschiffahrt, July 30.

The Rhön Soaring Flight Contest 1921 (Rhön-Sefelflug-Wettbewerb 1921), Werner v. Langsdorff. Zeit. für Flugtechnik u. Motorluftschiffahrt, vol. 12, no. 18, Sept. 30, 1921, pp. 278–281. List and data of competing machines and account of performances.

Spinning Curves. Flight and Spinning Curves (Flug- und Trudelkurven), Ludwig Hopf. Zeit. für Flugtechnik u. Motorluftschiffahrt, vol. 12, no. 18, Sept. 30, 1921, pp. 273–278, 9 figs. Discusses equilibrium in connection with stationary curve flight (spinning curve).

FLOW OF AIR

Phenomena. Flow Phenomena in Free Air Currents (Ueber die Strömungsvorgänge), Walter Zimm. Forschungsarbeiten auf dem Gebiete des Ingenieurwesens, no. 234, 1921, 36 pp., 31 figs. Investigation of flow phenomena in air currents of low velocity which are said to be of physical and technical importance. Description of experimental apparatus and results of experiments.

FLOW OF FLUIDS

Laminary Limit Flow. The Approximative Integration of the Differential Equation of the Laminary Limit Flow (Zur näherungsweisen Integration der Differentialgleichung der laminaren Grenzschicht), K. Pohlhausen. Zeit. für angewandte Mathematik u. Mechanik, vol. 1, no. 4, Aug. 1921, pp. 252–268, 10 figs. An integration method is developed and examples are given to demonstrate its applicability.

Laminary and Turbulent Friction. Laminary and Turbulent Friction (Ueber laminare und turbulente Reibung), th. v. Kármán. Zeit. für angewandte Mathematik u. Mechanik, vol. 1, no. 4, Aug. 1921, pp. 233–252, 7 figs. Discusses theory of laminary friction of liquids and gases in pipes, in connection with which author seeks to explain from mathematical and physical viewpoint the basic principle of Prandtl's limit flow theory and suggests a method for simple mathematical calculation of even complicated cases; he seeks also to develop mathematical basis for turbulent friction.

FLUE-GAS ANALYSIS

Numerical Calculation. The Evaluation of Flue-Gas Analysis (Die Auswertung der Rauchgasanalyse), A. B. Helbig. Feuerungstechnik, vol. 9, no. 24, Sept. 15, 1921, pp. 229–234. Based on calculation of decomposition of all combustible components of fuel with exception of carbon monoxide in atomic volumes, a formula applicable to all fuels is developed which permits an entirely new, simple and clear calculation of heat, according to which carbon loss is determined in purely mathematical manner, and which also permits a new criterion of fuels.

Testing Apparatus. Apparatus for Testing Flue-Gas, John B. C. Kershaw. Combustion, vol. 5, no. 5, Nov. 1921, pp. 204–207 and 218, 9 figs. Describes seven gas-testing instruments which depend upon the measurement of some physical property of waste-gases, which also serves as an index of the amount of CO_2 contained in them.

FORGE PLANTS

Safety Guards in Shops. Using Safety Devices in Forge Shops. Iron Trade Rev., vol. 69, no. 19, Nov. 10, 1921, pp. 1216–1217, 6 figs. Describes simple and inexpensive guards which are being used in one shop.

FOUNDATIONS

Steam Power Plants, etc. Some Notes on Foundation Plans, Douglas Wilson. Mech. World, vol. 70, no. 1816, Oct. 21, 1921, pp. 327–328, 6 figs. Discusses foundations for prime movers, steam power installations, steam turbines, concrete and reinforcement.

FOUNDRIES

Equipment. Equipment Features Malleable Shop, H. E. Diller. Foundry, vol. 49, no. 20, Oct. 15, 1921, pp. 805–813, 14 figs. Discusses changes made in conveying, melting and annealing at new foundry of Am. Chain Co., York, Pa.

Steel. Famous British Works. Eng. Production, vol. 3, no. 54, Oct. 13, 1921, pp. 338–339, 2 figs. Details of plant and equipment of steel foundry of Edgar Allen & Co., Ltd., Tinsley, for production of high-speed, carbon and alloy tool steels, special alloy steels for automobiles and aircraft, toughened steel castings for engineering and other purposes, dynamo magnet-steel castings, Imperial manganese steel, etc.

Temperature Problems. Temperature Problems in Foundry and Melting Room, John P. Goheen. Trans. Am. Inst. Min. & Metallurgical Engrs., no. 1105-N, 1921, 5 pp. Notes on pyrometer equipment for electric brass-melting furnace; special equipment for brazing brass; core-oven temperature control; and value of annealing. Abstract in Min. & Metallurgy, no. 179, Nov. 1921, p. 36.

FUELS

Gaseous. Gaseous Fuel in the Shipbuilding World, George Keillor. Gas Jl., vol. 156, no. 3047, Oct. 5, 1921, pp. 34–37. Discusses application in annealing, hardening and normalizing, billet, plate and rivet heating; core and mold drying; fuel consumption. See also Iron & Coal Trades Rev., vol. 103, no. 2796, Sept. 30, 1921, pp. 476–478.

Lumber Refuse. Consumers Central Heating Company's New Hog-Fuel Burning Plant. Power, vol. 54, no. 20, Nov. 15, 1921, pp. 750–753, 6 figs. Hog fuel, consisting of sawdust, shavings, groundup edgings, slabs and trimmings, is purchased from lumber manufacturing plants for fuel. Three 7500-sq. ft. vertical water-tube boilers installed. Fuel delivered by barges and handled by 5-ton electric monorail-operated clamshell bucket to system of conveyors.

Smokeless, Manufacture of. The Manufacture of Smokeless Fuel. Engineering, vol. 112, no. 2913, Oct. 28, 1921, pp. 596–601, 41 figs., partly on supp. plate; also Engineer, vol. 132, no. 3435, Oct. 28, 1921, p. 464, 3 figs. Describes works of low Temperature Carbonization, Ltd., Barugh, England, which has 20 retorts in continuous service and are carbonizing 36 tons of coal daily. Fuel produced is sort of semi-coke carrying only very small proportion of breeze, and is called coalite.

[See also OIL FUEL; PULVERIZED COAL.]

FURNACES, BOILER

Forced-Draft Grates. New Forced-Draft Furnace Grate (Crux-Rost und -Ventisolotor), H. Pradel. Elektrotechnischer Anzeiger, vol. 38, no. 153, Sept. 27, 1921, pp. 1096–1098, 7 figs. Describes forced-draft grate and direct-operating mechanical induced-draft installations recently placed on market by Hans Cruse & Co., Berlin.

FURNACES, HEATING

Reheating. The Development and Perfection of the Reheating Furnace (Der Tiefherdofen, seine Entwicklung und Vervollkommnung), A. Sattmann. Feuerungstechnik, vol. 9, no. 23, Sept. 1, 1921, pp. 217–219, 2 figs. Notes on operation and advantages of such furnaces.

FURNACES, INDUSTRIAL

Oil Burners. The "Rotamisor" Oil-Fuel Burner. Engineering, vol. 112, no. 2914, Nov. 4, 1921, pp. 631–632, 4 figs. Describes burner constructed by Combustions, Ltd., Kingston-on-Thames, most interesting feature of which is said to be method adopted for atomization. It is being developed to all requirements from heating of small muffle furnaces for tempering, etc., to firing of large marine or stationary boilers.

FURNACES, METALLURGICAL

Smelting. Smelting Furnace Practice with Regard to Different Construction Types and Present Conditions (Der Schmelzofenbetrieb unter Berücksichtigung der verschiedenen Ofenkonstruktionen und der heutigen Verhältnisse), Carl Rein. Giesserei-Zeitung, vol. 18, nos. 22 and 23 Sept. 6 and 13, 1921, pp. 296–300 and 312–314, 12 figs. Author records his experiences since 1919, and discusses furnace systems, charging methods and devices, and removal of iron. Points out noticeable defects in present smelting practice and furnaces and offers suggestions for their elimination. Address before Assn. German Foundrymen.

Tar-Oil-Fired. German Furnaces Fired with Tar-Oil, Kuenscher. Foundry, vol. 49, no. 19, Oct. 1, 1921, pp. 770–771. (Abstract.) Paper read before Assn. of German Non-ferrous Metal Founders.

G

GAGES

Manufacturing Uses. The Need of Gauges for Modern Manufacturing, A. C. Wickman. Can. Machy., vol. 26, no. 13, Sept. 29, 1921, pp. 25–29, 8 figs. Discusses the subject of gaging screws, and the checking of gages.

McLeod. An Extension of the Range of the McLeod Gauge, A. H. Pfund. Physical Rev., vol. 18, no. 1, July 1921, pp. 78–82, 2 figs. The pressure of the gas forced into capillary is measured by means of a hot-wire gage. The ratio of compression being known, the time pressure can be determined.

Precision. Precision Gauges, M. E. Kanek. Mech. World, vol. 69, no. 1782, Feb. 25, 1921, pp. 139–141. Discusses 81-block sets, types on the market, effect of size on accuracy, material for gages, direct and comparative methods of measuring, etc.

Snap. Systems of Gauging. Eng. Production, vol. 3, no. 54, Oct. 13, 1921, pp. 345–346, 2 figs. Describes an adjustable snap gage and setting micrometer, which is said to be adaptable and inexpensive.

GAS PRODUCERS

Fuel Economy. Fuel Saving in Modern Gas Producers and Industrial Furnaces, W. B. Chapman. Mech. Eng., vol. 43, no. 11, Nov. 1921, pp. 717–621, 7 figs. Calls attention to fuel wastes in industries using gas producers and producer-gas furnaces, reviews progress in last 25 years in gas-producer construction, and describes distinctive type of recuperative furnace and extension of its use to pulverized coal and oil. (Abstract.)

GEAR CUTTING

Gear Shapers. Production Shaping. Machy. (N. Y.), vol. 28, no. 3, Nov. 1921, pp. 186–190, 10 figs. Use of shapers in production work in machine-tool building plants.

Machines. An Improved Gear Generating Machine. Eng. Production, vol. 3, no. 57, Nov. 3, 1921, pp. 412–415, 7 figs. Details of novel design for helical, straight and internal gears.

GEARS

Erosion in High-Speed. Pitting in High-speed Gearing. Machinery (Lond.), vol. 19, no. 472, Oct. 13, 1921, pp. 50–51, 2 figs. Discusses new method developed to eliminate pitting or erosion in teeth of wheels.

Hardening under Pressure. Hardening Gear Under Pressure. Eng. Production, vol. 3, no. 57, Nov. 3, 1921, pp. 426–427, 3 figs. Describes new method.

Involute. The Evolution of the Involute Gear Tooth—VIII and IX, A. Fisher. Machinery (Lond.), vol. 19, nos. 474 and 475, Oct. 27 and Nov. 3, 1921, pp. 101–103, 6 figs. and pp. 132–136, 7 figs. Involute pitch and pressure angle permatability.

Non-Metallic. Design and Manufacture of Non-metallic Gears. Machinery (Lond.), vol. 19, no. 471, Oct. 6, 1921, pp. 6–11, 12 figs. Discusses preparation of rawhide and fabric-base gear materials physical characteristics, design and machining of gear.

Power-Transmission. Gear Tooth Problems (Beitrag zur Zahnradfrage für Uebersetzungsgetriebe), O. Lasche. Zeit. des Vereines deutscher Ingenieure, vol. 65, no. 42, Oct. 15, 1921, pp. 1087–1088, 8 figs. Based on examples of gear teeth for marine and land installations, values for tooth loads and speeds are developed. Sliding conditions with standard and AEG (German Gen. Elec. Co.) teeth are compared. Suggests means of obtaining a neater and more accurate tooth.

Spur. The Production of Spur Gears, R. Waring-Brown. Eng. Production, vol. 3, no. 55, Oct. 20, 1921, pp. 364–368, 8 figs. and (discussion), no. 56, Oct. 27, 1921, pp. 389–391. Comparison of modern methods. Paper presented before Instn. Production Engrs.

Spur, Hobbed, Backlash in. Backlash in Hobbed Spur Gears, Carl G. Olson. Machy. (N. Y.), vol. 28, no. 3, Nov. 1921, pp. 222–224, 5 figs. Amount of backlash recommended to provide for unavoidable inaccuracies in machining and heat treatment.

Sykes Gear-Tooth Comparator. The Sykes Gear-Tooth Comparator. Mech. World, vol. 70, no. 1814, Oct. 7, 1921, pp. 280–282, 4 figs. May be used for comparing and definitely measuring thickness of teeth, for comparing uniformity of pitch and for ascertaining amount of inaccuracy of tooth shape.

GOVERNORS

Shaft, Adjusting. Adjusting Shaft Governors. Power, vol. 54, no. 17, Oct. 25, 1921, pp. 641–647, 16 figs. Shows how to adjust different types of governors.

GRINDING MACHINES

Surface. Economy of Surface Grinding Machines (Wirtschaftlichkeit der Flächenschleifmaschinen), F. Warsow. Betrieb, vol. 3, no. 25, Sept. 15, 1921, pp. 829–832, 6 figs. Describes machines equipped with grinding cylinders for economical machining of various flat pieces from the rough. Comparison of results show a much higher efficiency with described machines than with those operating with circumferential grinding disks with equal neatness and precision.

H

HANDLING MATERIALS

Equipment. A Survey of Material-Handling Equipment, R. H. McLain. Chem. Age (N. Y.), vol. 29, no. 10, Oct. 1921, pp. 427–431, 25 figs. Suggestions for the use of labor-saving devices in chemical manufacture.

HANGARS

Cape May. Cape May Hangar for Dirigible Built From Two Small Ones. Eng. News-Rec., vol. 87, no. 17, Oct. 27, 1921, pp. 698–700, 4 figs. Sheds at Montauk and Cape May reërected on new base sections to produce hangar of greater capacity.

Suspended Roofs. Large Roofs Suspended by Cables To Avoid Columns. Eng. News-Rec., vol. 87, no. 17, Oct. 27, 1921, pp. 638–639, 4 figs. Novel design of airship sheds, giving unobstructed full-length side openings. Translated from Génie Civil.

HEAT TRANSMISSION

Bibliography. Bibliography on Heat Transmission. Am. Soc. Refrig. Engrs. Jr., vol. 8, no. 2, Sept. 1921, pp. 150–162.

Theory for Turbulent Streams. Transmission of Heat from Solid Bodies to Turbulent Liquid or Gas Streams (Der Wärmeübergang an einen turbulenten Flüssigkeits- oder Gasstrom), H. Latzko. Zeit. für angewandte Mathematik u. Mechanik, vol. 1, no. 4, Aug. 1921, pp. 268–290, 10 figs. Based on laws of velocity distribution of turbulent streams developed by Prandtl and v. Kármán, attempt is made to develop systematically a theory of heat transmission for turbulent streams and of dependence of heat-transmission coefficient on shape and dimensions.

HEATING, ELECTRIC

Arc and Resistance. Arc vs. Resistance Heating (Lichtbogen- oder Widerstandsbeheizung), H. Wintermeyer. Elektrotechnischer Anzeiger, vol. 38, nos. 155, 156, 147 and 158, Sept. 29, Oct. 1, 4 and 5, 1921, pp. 1109–1110, 1115–1116, 1125–1126 and 1133–1134, 8 figs. Discusses most important features in connection with industrial arc and high- and low-current resistance heating.

Gas Heating vs. Comparison of Gas and Electric Heating (Comparaison du chauffage au gas et a l'électricité, A. Grebel. Le Génie Civil, vol. 79, no. 12, Sept. 17, 1921, pp. 249–252. Compares 1 kg. of coal transformed with low tension electricity and into gas and by-products. Shows that cost of production is in favor of gas.

HEATING, HOT-WATER

Electric. Electric Hot-Water Heating Plants with Heat Storage for Schoolhouses (Elektrische Warmwasser-Heizanlagen mit Wärme-Akkumulierung für Schulhäuser). Schweizerische Bauzeitung, vol 78, no. 13, Sept. 24, 1921, pp 151–153, 7 figs. Describes hot-water heating system installed in two schoolhouses in Aarau, Switzerland, in which electric current of 4000 volts is employed. Points out success and advantages of system.

HEATING, STEAM

Isolated Power Plant. Heating and Its Relation to Isolated-Plant Operation, E. L. Wilder. Power, vol. 54, no. 20, Nov. 15, 1921, pp. 758–761, 8 figs. Discusses factors that make for efficiency and inefficiencies in a combined power and heating plant.

Radiation, Calculation of. Radiation Calculation Charts, D. N. Crosthwait, Jr. Heat. & Vent. Mag., vol. 18, no. 10, Oct. 1921, pp. 27–29, 2 figs. Gives tables of square feet of direct cast iron-steam radiation for heat loss through two-pane windows, and through wall area, room temperature 70 deg. fahr. and outside temperature 0 deg. fahr. and explains application.

Stationary Heat Storage. A Steam Heating Plant with Stationary Heat Storage (Eine Dampfheizanlage mit festem Wärmespeicher), M. Hottinger. Schweizerische Bauzeitung, vol. 78, no. 10, Sept. 3, 1921, pp. 124–126, 2 figs. Results of tests carried out on electric heating installation in spinning mill of H. Bühler & Cie., Sennhof, Switzerland, described in previous issue of same Journal (July 17, 1920).

Vacuum. Operation and Advantages of Vacuum Steam-Heating Systems (Vorzüge und Wirkungsweise der Vakuumdampfheizungen). Elektrotechnischer Anzeiger, vol. 38, nos. 161 and 162, Oct. 11 and 12, 1921, pp. 1158–1160 and 1164–1165. Said to be especially adapted to small and medium-size factories.

HOBS

Gear. Inspection of Involute Spur and Helical Gear Hobs. Machinery (Lond.), vol. 19, no. 474, Oct. 27, 1921, pp. 90–95, 19 figs. Testing accuracy of hob and tooth parts; hobbing test.

HOISTING MACHINES

Safeguards. Hoisting and Conveying. Power Plant Eng., vol. 25, no. 20, Oct. 15, 1921, pp. 1000–1003. Machinery safeguards and safe operation.

HOT-WATER SUPPLY

Water-Temperature Control. Determination of Hot Water Requirements, William Wilcox. Heat. & Vent. Mag., vol. 18, no. 10, Oct. 1921, pp. 31–35, 7 figs. Essential points to be considered, with data on apartment houses and various methods of water-temperature control.

HOUSES

Wall Construction. Design and Construction of Dwelling House Walls, Carroll Beale. Concrete Products, vol. 21, no. 4, Oct. 1921, pp. 51–52. Discusses types of construction, including concrete. Reprinted from Contractor's Atlas.

HOUSING

Garden City Scheme, London. Building Garden-Cities at the London Conférence (La Construction des Villeset Cités-Jardins a la conference de Londres), M. De Heem. Annales des Travaux Publics de Belgique, vol. 22, no. 4, August 1921, pp. 595–626, 11 figs. Partly on supp. plates. Discusses the housing question and recent competition in designs in London. Gives illustrations.

Sherbrooke, Can. Housing Developments in Sherbrooke. Contract Rec., vol. 35, no. 45, Nov. 9, 1921, pp. 968–969, 8 figs. Model city built to house workers of Canadian Connecticut Cotton Mills.

HYDRAULIC MACHINERY

Packing Friction. Experiments with Packing Friction (Versuche über Stulpenreibung), Eugen Irion. Zeit. des Vereines deutscher Ingenieure, vol. 65, no. 39, Sept. 24, 1921, pp. 1016–1017, 2 figs. Results of tests on a 75-ton drop and bending machine with hydraulic gage connected directly to working cylinder. Comparison with values determined by Martens. Advantages of the simplified pressure measurement with measuring cylinders.

HYDRAULIC TURBINES

Draft Tubes. Draft Tubes—How They Operate and Why. Power, vol. 54, no. 16, Oct. 18, 1921, pp. 600–604, 17 figs. Elementary, non-mathematical explanation of hydraulic draft tubes. Use of barometer and "scenic railway" to illustrate fundamental principles involved.

Kaplan. Design and Use of the Kaplan Turbine (Die Kaplanturbine in Ausführung und Verwendung), C. Reindl. Zeit. des Vereines deutscher Ingenieure, vol. 65, nos. 40 and 41, Oct. 1 and 8, 1921, pp. 1035–1040 and 1066–1069, 33 figs. Deals with development and details, including rotars, guide vanes, draft tubes, single and double turbines. Experimental results and behavior under different operating conditions. Useful possiblities and advantages.

Speed Regulation. Speed Regulation of Hydraulic Turbines, John S. Carpenter. Power Plant Eng., vol. 25, nos. 19 and 20, Oct. 1 and 15, 1921, pp. 947–950 and 990–993, 5 figs. Principles and methods of calculation involved in design of hydraulic turbine governors.

Speed Regulation in the Hydraulic Plant, N. L. Devendorf. Power, vol. 54, no. 20, Nov. 15, 1921, pp. 764–767, 6 figs. Conditions that must be met by waterwheel governor. Development from early flyball governor to present oil-pressure type. Requirements of low-head versus high-head plants. Operating in parallel.

HYDROELECTRIC DEVELOPMENT

Belgium. Utilizing Hydraulic Resources of Belgium (Avant-Projet de captation des energies hydrauliques Belges), Herman Chauvin. Révue Universelle des Mines, vol. 11, no. 1, Oct. 1, 1921, pp. 1–28, 9 figs. Describes Ardennais works, reservoirs, dams, canals, power plants, their cost, capacity, equipment, etc.

Colorado River. Electrical Construction Plan for Colorado River, Charles Heston Peirson. Elec. Rev. (Chicago), vol. 79, no. 16, Oct. 15, 1921, pp. 586–588. Comprehensive development proposed to regulate stream flow for utilization of available water power.

Switzerland. Plans for Hydroelectric Development in the Bernese Oberland (Les projets des Forces Motrices Bernoises dans l'Oberhasle), Jean Ganguillet. Schweiz. Elektrotechnischer Verein Bul., vol. 12, no. 8, Aug. 1921, pp. 209–216, 2 figs. Presents plans for harnessing the Aar River and for developing in Oberhasle the future greatest source of electric energy in Switzerland.

HYDROELECTRIC PLANTS

California. Progress on Pit River Project in California. Eng. News-Rec., vol. 87, no. 15, Oct. 13, 1921, pp. 604–606, 1 fig. First plants completed. Features of development will be 220,000-volt transmission line, 7-mi., 3000-sec-ft. tunnel on Pit River No. 5, and 40,000-hp. reaction turbines under 454-ft. head in Pit River No. 1.

Great Falls, Conn. Great Falls Hydro-Electric Development. Power Plant Eng., vol. 25, no. 20, Oct. 15, 1921, pp. 981–986, 11 figs. Describes equipment of Falls Village hydroelectric plant of Conn. Power Co., on Housatonic River, supplying normally 10,000 kw. at 66,000 volt, to main lines.

Italy. Hydroelectric Plants in Southern Italy (Gli impianti idroelettrici del Mezzogiorno d'Italia), Emirico Vismara. L'Elettricista, vol. 10, no. 18, Sept. 15, 1921, pp. 137–140, 4 figs. Discusses power transmission problems in connection with irrigation.

Maximum Rates. Determination of Maximum Rates for Hydroelectric Power Centrals (La fixation des tarifs maxima dans les cahiers des charges des concessions d'énergie hydraulique), G. Tochon. Révue Générale de l'Électricité, vol. 10, no. 13, Oct. 1, 1921, pp. 451–455. Discussion of standard specification for maximum rates proposed by Ministry of Public Works.

Sicily. Brief Description of the Works of the Societa Generale Elettrica of Sicily (Descrizione sommaria degli impianti della Società Generale Elettrica della Sicilia). L'Elettrotecnica, vol. 8, no. 27, Oct. 5, 1921, pp. 604–610, 9 figs. Discusses hydroelectric construction, power houses and equipment, and system of transmission lines.

I

ICE PLANTS

Brine Agitation. Modern Propeller Design for Brine Agitation and Circulation, E. A. Burrows. Am. Soc. Refrig. Engrs. Jl., vol. 8, no. 2, Sept. 1921, pp. 127–133 and (discussion) 133–134, 10 figs. Describes experiments with Halvorsen propeller, reducing power consumption from 25 to 50 per cent.

INDEXES

Construction and Comparison. Details of Index Number Construction and Comparison of Indices. E. E. George. Eng. & Contracting, vol. 56, no. 19, Nov. 9, 1921, pp. 431–434, 3 figs. Notes on volume of production index. Bradstreet's, Dun's, and Federal Reserve Board index, standard and tests, and cost-of-living indexes.

INDUSTRIAL MANAGEMENT

Distribution of Manufacturing Expense. The Distribution of Manufacturing Expense, C. Haigh. Can. Machy., vol. 26, no. 15, Oct. 13, 1921, pp. 34–36. Discusses five methods for distributing overhead expense: man-rate; man-hour; material and labor; sold-hour; and machine-hour rate.

Factory Investigation. How Factory Investigations Reduce Costs, Albert A. Dowd and Frank W. Curtis. Machy. (N. Y.), vol. 28, no. 3, Nov. 1921, pp. 208–212, 7 figs. Discusses effect of design upon cost of machining and gives examples of savings realized by change of design; savings effected in drilling, and by use of punch press.

Instruction Sheets. Proposals for New Factory Instruction Sheets (Entwurfe neuer Betriebsblätter). Betrieb, vol. 3, no. 25, Sept. 15, 1921, p. 160. Proposal of Works Dept. of German Federation of Technical and Scientific Societies for care and handling of automobile tires.

Proposals for New Factory Instruction Sheets (Entwürfe neuer Betriebsblätter). Betrieb, vol. 3, no. 26, Sept. 25, 1921, pp. 166–168. Proposals of Works Dept. of German Federation of Technical and Scientific Societies for care and handling of precision ball and roller bearings; installation, operation and care of transmissions.

Material Control. Material Control for the Small Industrial Plant, Henry C. Haskell. Indus. Management, vol. 62, no. 5, Nov. 1921, pp. 271–273, 1 fig. Describes simple, direct and logical method of approaching problem. Includes illustration of stock card used in system which includes material costing, ordering and planning.

Purchasing Department. Purchasing. A. B. Johnson. Paper, vol. 28, no. 19, July 14, 1921, pp. 17–19, 28 and 38. Discusses work and organization of purchasing departments. Paper read before Superintendents' Assn.

Scientific. Scientific Management—XXXII, Henry Atkinson. Eng. & Indus. Management, vol. 6, no. 15, Oct. 13, 1921, pp. 400–401 and 403. Failures of scientific management and their cause.

Stores Records. Machine-Posted Balance of Stores Records, C. Moffitt Ford. Bul. Taylor Soc., vol. 6, no. 4, August 1921, pp. 139–152, 4 figs. Discusses mechanical equipment and card design; posting of cards; method of proof; filing, posting and verifying routine; etc. Paper read before Phila. Section of Taylor Soc.

Tool Handling. The Handling of Metal-Cutting Tools (Die Behandlung der Werkzeuge in derFabrik), A. Fattler. Zeit. des Vereines deutscher Ingenieure, vol. 65, no. 41, Oct. 8, 1921, pp. 1063–1065, 3 figs. Notes on materials for tools; storage and distribution in factory; repair and renewal: hardening of tools.

[See also TIME STUDY.]

INDUSTRIAL ORGANIZATION

Reorganizing Small Works. Reorganizing the Small Works, H. N. Munro. Eng. & Indus. Management, vol. 6, no. 17, Oct. 27, 1921, pp. 459–462, 9 figs. Writer demonstrates importance of forming clear idea of conditions of working, capabilities of staff, and proper location and layout of plant, in describing practical system of reorganization. Notes on planning organization chart.

Stimulating Interest of Workers. Making Work Fascinating as the First Step Toward Reduction of Waste, Walter N. Polakov. Mech. Eng., vol. 43, no. 11, Nov. 1921, pp. 731–734 and 765, 7 figs. Points out that such experiments as have been already conducted in uniting brain work with manual work have proved beyond any doubt that such a course liberates dormant or suppressed creative capacities of men, improves quality and quantity of production, and, above all, substantially ameliorates industrial relations. Advantages to owner and labor groups are set forth. (Abstract.)

INDUSTRIAL RELATIONS

Coöperation. Experiments in Industrial Coöperation. Iron Age, vol. 108, no. 19, Nov. 10, 1921, pp. 1207–1208. Constructive solutions of employer-employee relations presented at meeting of Acad. of Political Science.

Economic Axioms. The Economic Axioms of Industry, E. W. Petter. Eng. & Indus. Management, vol. 6, no. 18, Nov. 3, 1921, pp. 500–502. Notes on creation and unequal distribution of wealth; community's well-being; employer and worker; piece-work rates; unemployment doles and waste; how the State can assist. (Abstract.) Lecture arranged by Indus. League & Council.

Human Factor. The Human Factor in Industry—II, Clarence H. Northcott. Indus. Management, vol. 62, no. 5, Nov. 1921, pp. 292–297, 4 figs. Points out importance of weighing physical and mental differences and study of job in vocational selection. Discusses motion study, fatigue, rest periods, etc.

Industrial Court, Great Britain. The Industrial Court of Great Britain and Ireland, R. W. Patmore. Indus. Management, vol. 62, no. 5, Nov. 1921, pp. 269–271. Its history, functions and personnel.

INTERNAL-COMBUSTION ENGINES

Carburation. Study of Carburation, Thermodynamics of the Explosion Engine (Introduction à l'étude de la carburation, pyrodynamique du moteur a explosions), M. Carbonaro. Memoirs et Compte Rendu des Travaux de la Société des Ingenieurs Civile de France, vol. 74, no. 4–5–6, April-June 1921, pp. 185–249, 13 figs. Discusses deflagration at constant pressure, ignition temperature, flame propagation and its velocity, etc.

Cooling-Water Systems. Cooling-Water Systems for Internal Combustion Engines, Edgar J. Kates. Power, vol. 54, no. 20, Nov. 15, 1921, pp. 710–713, 4 figs. Notes on quality of water use of cooling tanks; open cooling systems and their faults; inclosed cooling systems.

Increasing Power Output. Petrol Engine Performance. Times Eng. Supp., no. 564, Oct. 1921, p. 277. Notes on increasing power output.

Supercharging. Supercharging Engines, C. H. T. Alston. Automobile Engr., vol. 11, no. 155, Oct. 1921, pp. 337–341, 2 figs. Discusses advantages and disadvantages; its application to aircraft, road motor vehicles, marine, stationary, and portable engines; etc.

[See also AIRPLANE ENGINES; DIESEL ENGINES; KEROSENE, OIL ENGINES, SEMI-DIESEL ENGINES.]

IRON

Gray, Oxygen in. Discusses Problems of the Foundry, J. Shaw. Foundry, vol. 49, no. 19, Oct. 1, 1921, pp. 759–761. Discusses differing view of metallurgists regarding effect of oxygen in gray iron. Methods of making physical tests and their effects on results are pointed out.

Oxygen in, Determination. A New Method for the Determination of Oxygen in Iron (Ueber ein neues Verfahren zur Bestimmung des Sauerstoffs im Eisen), P. Oberhoffer and O. von Keil. Stahl u. Eisen, vol. 41, no. 41, Oct. 13, 1921, pp. 1449–1453, 6 figs. By employment of new method, iron- and manganese-oxygen compounds in all mixture proportions can be completely reduced; with iron- and silicium-oxygen, compounds, whose silicic-acid contents do not exceed 20 per cent, at least 93 per cent of total oxygen content can be reduced.

Pig and Cast, Composition of. Composition of Pig Iron and of Cast Iron, Y. A. Dyer. Iron Age, vol. 108, no. 20, Nov. 17, 1921, pp. 1267–1270. Chemical and structural composition. Various elements, their characteristics and effect on metal. Oxygen in iron. .

IRON AND STEEL

Tests. Experiments on Properties of Iron and Steel to Resist Wear (Undersökning förande järns och ståls samt en del andra kroppars förmåga att motstå nötning), J. A. Brinell. Jernkontorets Annaler, vol. 105, no. 9, 1921, pp. 347–398, 22 figs. Describes series of tests made, and abrasives used; gives table of results.

IRON CASTINGS

Reversed Chilled. Steel Addition to Pig Iron and Reversed Chilled Casting (Stahlzusatz zum Roheisen und der umgekehrte Hartguss), E. Piwowarsky. Giesserei-Zeitung, vol. 18, no. 26, Oct. 3, 1921, pp. 356–359, 7 figs. Writer seeks to establish relation between chemical analyses and the congealing diagram of iron-carbon alloys. Bibliography.

IRON, PIG

Mixer. Pig Iron Mixer. Eng. Progress, vol. 2, no. 10, Oct. 1921, pp. 227–230, 8 figs. Advantages of mixing process; rolling and tilting mixer; electrical tilting device.

Synthetic. Synthetic Foundry Pig Irons in Germany. Iron Age, vol. 108, no. 18, Nov. 3, 1921, pp. 1137–1138. Methods of production during war to overcome scarcity of low phosphorus irons; their properties; charcoal iron. Translated from Stahl u. Eisen, June 30, 1921.

K

KEROSENE

Carburation. Carburation of Kerosene and the Action of the Walls (La carburation par le petrole lampant et l'action de paroi), G. Lumet. Memoirs et Compte Rendu des Travaux de la Société des Ingénieurs Civils de France, vol. 74, no. 3–5–6, April-June, 1921, pp. 291–300. Discusses effect of cooling the walls and gives results of tests made, also tables.

L

LABOR

Hours of Work. The Eight Hour Law (La Loi des Huit Heures), Léon Repriels. Révue Universelle des Mines, vol. 10, no. 6, Sept. 15, 1921, pp. 654–676. Discusses its provisions and its application, and why Belgium cannot ratify the Washington eight-hour convention.

Organization. The Purpose of the Labor Articles in Automotive Industries, Harry Tipper. Automotive Industries, vol. 45, no. 15, Oct. 13, 1921, pp. 732–733. Points out necessity for studying human side of production activities with a view to preventing trouble rather than waiting for difficulties to arise and then attempting to find a remedy. Production cost depends largely upon human organization.

LABOR TURNOVER

Problem. A Common Sense Attack on Turnover, James R. Adams. Indus. Managment, vol. 62, no. 5, Nov. 1921, pp. 298–302, 4 figs. Writer tells what has been done by Studebaker Corp. under present conditions, to make employees appreciate management's problems and to enlist their intelligent coöperation for the common good.

LABORATORIES

Applied Mechanics. A Laboratory of Applied Mechanics (Notice sur le Laboratoire de Mécanique appliquée), J. Boulvin, F. Keelhoff, G. Van Engelen, O. Steels. Annales de l'Association des Ingénieures Sortis des Écoles Spéciales de Gand, vol. 11, 5th Series, 1921, pp. 130–148. Discusses its functions, and equipment for teaching purposes.

Gas. The Industrial Laboratory of the Bourbonnais Co. (Le Laboratoire industriel de la Compagnie du Bourbonnais), J. H. Brodin. Chaleur et Industrie, vol. 2, no. 12, Sept. 1921, pp. 554–560, 4 figs. Discusses development and equipment dedicated to gas interests.

Scientific Industrial Research. A Modern Scientific Industrial Research Laboratory and Its First Results (Un exemple de laboratoire moderne pour recherches de science industrielle; ses premiers résultats), Georges Baume. Révue Générale de l'Électricité, vol. 10, no. 12, Sept. 24, 1921, pp. 396–398. Discusses laboratory of Société de Recherches et Perfectionnements Industriels, founded in 1919 at Puteaux, and how it works.

LATHE TOOLS

Circular Form Tools. Designing Circular Form Tools. Eng. Production, vol. 3, no. 55, Oct. 20, 1921, pp. 370–371, 2 figs. Describes use of practical formulas.

Apron Design. Lathe Aprons, A. Clegg. Eng. Production, vol. 3, no. 55, Oct. 20, 1921, pp. 373–378, 12 figs. Comparison between typical English and American designs.

Economical Operation. Study of Economical Lathe Operation with Special Regard to the Cutting Pressure (Ein Beitrag zur Erforschung der Wirtschaftlichkeits an Drehbänken unter besonderer Berücksichtigung des Schnittdruckes), Herbert Sack. Betrieb, vol. 3, no. 25, Sept. 15, 1921, pp. 800–813, 21 figs. Investigation of effective power and its dependence on feed and depth of cut in connection with detachment of chip. A diagram is developed from which the cutting speed for cross-section of every chip can be obtained.

Feed Reverse Mechanisms. The Design of Feed Reverse Mechanisms for Lathes, A. Clegg. Machinery (Lond.), vol. 19, no. 472, Oct. 13, 1921, pp. 34–39, 13 figs. Discusses the tumbler, fixed center, bevel, and planetary or epicyclic gears, and their advantages and disadvantages.

Headstock Design. Improved Lathe Headstock Details and their Jigs, Hubert Bentley. Eng. & Indus. Management, vol. 6, no. 15, Oct. 13, 1921, pp. 398–399, 4 figs. Describes very simple and successful type of spring-locking bolt and jig employed to ensure accuracy in drilling of locking bolt holes in both cone and gear wheel.

"Non-Stop" Methods. Devices for Repetition Work. Eng. Production, vol. 3, no. 56, Oct. 27, 1921, pp. 392–393, 4 figs. Describes certain non-stop methods, by means of which lathes or machines are kept running.

Oerlikon Works, Switzerland. Recent Machine-Tool Developments. Engineering, vol. 112, no. 2915, Nov. 11, 1921, pp. 652–656, 23 figs. Describes new lathes made by Swiss Machine-Tool Works, Oerlikon. Two designs are built, one with three-stepped belt cone pulley drive, and one with single-pulley, and all-geared head.

Turret. Production Work in the Locomotive Shop. Machy. (N. Y.), vol. 28, no. 3, Nov. 1921, pp. 228–230, 3 figs. Application of the Bullard vertical turret lathe.

Turret and High-Speed Lathes (Revolverdrehbank und Schnellidrehbank), R. Ende. Betrieb, vol. 3 no. 25, Sept. 15, 1921, pp. 789–797, 8 figs. Points out as an example that round parts can be as accurately machined on a turret as on a high-speed lathe, without employment of skilled labor required for latter machine. Thus initial increased cost of installation is often made up within a year's time.

LIFTING MAGNETS

German Type. Lifting Magnets (Lasthebemagnete). Glasers Annalen, vol. 89, no. 5, Sept. 1, 1921, pp. 54–56, 8 figs. Describes construction, handling and uses of lifting magnets, with special reference to the Demag (Duisburg, Germany) type.

LIGHTING

Exterior and Interior. Improved Practices in Exterior and Interior Illumination. Elec. World, vol. 78, no. 20, Nov. 12, 1921, pp. 971–974, 8 figs. Broadening applications of modern equipment yielding greater service to industry and homes.

Factory. Better Illumination Cuts Production Costs, Ward Harrison, Orville F. Haas and Fred W. Dopke, Elec. World, vol. 78, no. 16, Oct. 15, 1921, pp. 763–764, 2 figs. Test data show increase in production of 12.2 per cent due to installation of modern lighting system. Tests made by Dover Mfg. Co., Dover, Ohio.

LIGNITE

Water-Soluble Ash. Importance of Water-Soluble Ash in the Evaluation of Lignite (Wichtigkeit der wasserlöslichen Asche bei der Verwertung der Braunkohle), Th. Limberg. Feuerungstechnik, vol. 9, no. 22, Aug. 15, 1921, pp. 205–207. Points out importance of analysis of composition of ash, and discusses influence of water-soluble ash on the different products of lignite.

LOCOMOBILES

German Type. The Overtype Steam Unit, H. Keay Pratt. Mech. World, vol. 69, no. 1782, Feb. 25, 1921, pp. 141–143, 1 fig. Discusses development of locomobile by R. Wolf of Magdeburg, giving 1 b.hp. per lb. of coal in special trials. Advantages and details of operation.

LOCOMOTIVE BOILERS

Fire Tubes, Mounting. Mounting and Fixing Fire Tubes in Locomotive Boilers (Le montage et la fixation des tubes a fumée dans les chaudières de locomotives), H. Gallou. La Technique Moderne, vol. 13, no. 2, Feb. 1921, pp. 59–62, 12 figs. Describes new automatic apparatus for the purpose.

LOCOMOTIVES

Boosters. The Locomotive Booster As an Operating Factor. Ry. Rev., vol. 69, no. 15, Oct. 8, 1921, pp. 461–469, 16 figs. Results of tests made with five new Pacific and one Mikado types of locomotives fitted with boosters. Operating characteristics.

Economic Use of Steam. On the Question of the Economic Production and Use of Steam on Locomotives, Maurice Lacoin. Bulletin International Ry. Assn., vol. 3, no. 9, Sept. 1921, pp. 1157–1204, 35 figs. Discusses steam superheating and compounding, packings, valves, feedwater heating water-tube boilers, scale, combustion control, etc., Appendixes.

Economical Design. Avoidable Waste in Locomotive Operation as Affected by Design, James Partington. Mech. Eng., vol. 43, no. 11, Nov. 1921, pp. 729–730. Points out that best way to overcome waste is to design locomotive so that it will fulfill efficiency requirements of (1) a drawbar horsepower for minimum amount of fuel, (2) for minimum amount of weight of locomotive and tender, and (3) for minimum cost of repairs, and shows how these are secured. (Abstract.)

Feedwater Heating. Feed Water Heating on the London & North Western Railway. Ry. Gaz., vol. 35, no. 16, Oct. 14, 1921, pp. 572–574, 2 figs. Details of latest application of Weir feedwater heating system and pump to "George the Fifth" class of express locomotive.

Floating Bushings. The Development of Floating Bushings. Ry. Rev., vol. 69, no. 17, Oct. 22, 1921, pp. 535–538, 5 figs. Describes early development, and recent application to new locomotives built by Am. Locomotive Co.

Mallet. Virginian Mallet Locomotives. Ry. Jl., vol. 27, no. 10, Oct. 1921, pp. 12–13, 1 fig. Tractive power 147,200 lb. working compound and 176,600 lb. working simple; 2–10–10–2 type. Comparison with 2–8–8–2 type.

Mexican Railways. New Power for Rehabilitation of Mexican Railways. Ry. Rev., vol. 69, no. 18, Oct. 29, 1921, pp. 578–580, 5 figs. Baldwin builds nearly 100 locomotives comprising five distinct type for service on heavy grades. See also Ry. Age, vol. 71, no. 20, Nov. 1912, 21, pp. 937–939.

Northern Pacific. New Locomotives for the Northern Pacific. Ry. Age, vol. 71, no. 17, Oct. 22, 1921, pp. 767–769, 3 figs. Pacific type for heavy fast service. Mikados, mallets and switchers follow lines of earlier designs.

Operation. Traveling Engineers Present Valuable Reports. Ry. & Locomotive Eng., vol. 34, no. 10, Oct. 1921, pp. 265–271. Discusses operation and maintenance of oil-burning locomotives, self-adjusting wedges, feedwater heaters, devices for increasing tractive power, and operating stoker-fired locomotives. Report of Executive Committee.

Paulista Railway, Brazil. Electric Motive Power for Paulista Railway. Ry. Age, vol. 71, no. 16, Oct. 15, 1921, pp. 721–722, 3 figs. Describes electric freight and passenger locomotives for Brazil; tractive efforts at 25 per cent adhesion 58,500 lb. and 51,000 lb. respectively.

Thermic Siphons. The Installation and Operation of Thermic Syphons. Boiler Maker, vol. 21, no. 10

Oct. 1921, pp. 273–277, 12 figs. Discusses application to locomotives as an efficiency-promoting device.

Valve Gear. Poppet Valve Gear for Steam Locomotives (Weiteres über die Ventilsteuerung bei Dampflokomotiven), H. Wittfeld. Zeit. des Vereines deutscher Ingenieure, vol. 65, no. 44, Oct. 29, 1921, pp. 1141–1142, 10 figs. Supplementary to article in same journal (no. 24, p. 623), a special type of Lentz gear is described and compared with an older type.

LUBRICATION

Tests on Steam and Gasoline Engines. Comparative Lubrication Engineering. Sci. Lubrication, vol. 1, no. 9, Sept. 1921, pp. 18–21. Describes test on small-power Corliss engine, and on a Continental motor, giving some interesting dilution data.

LUBRICATING OILS

Castor and Mineral-Oil Mixture. Tests of Castor Oil and Mineral-Oil Mixtures on Gnome Rotary Engine, O. J. May and Howard Cooper. Sci. Lubrication, vol. 1, no. 9, Sept. 1921, pp. 10–14, 6 figs. U. S. Army Service report discussing method and results of tests made.

M

MACHINE CONSTRUCTION

Allowances. Determination of the Required Allowance Dimensions for Different Constructions (Feststellung der erforderlichen Passmasse für die verschiedenen Erzeugnisse), W. Kühn. Betrieb, vol. 3, no. 26, Sept. 25, 1921, pp. 406–411, 8 figs. Explains when limit gages should be used and how selection of allowance dimensions for a given construction piece should be made.

Record of Materials. Record of Materials Used in Machine Construction. Machinery (Lond.), vol. 19, no. 471, Oct. 6, 1921, pp. 1–3, 4 figs. Gives details of a "commodity book" in which are recorded all materials and standard parts used by the firm, these records are kept up-to-date. Various advantages are claimed for this book.

MACHINE SHOPS

English. Famous British Works. Eng. Production, vol. 3, nos. 55, 56 and 57, Oct. 20, 27 and Nov. 3, 1921, pp. 362–363, 4 figs., 386–388, 4 figs., and 410–411, 2 figs. Oct. 20: Worcester works of Heenan & Froude, Ltd., for manufacture of Froude dynamometers, Heenan air filters, oil and water coolers, refuse destructors, and refrigerating machinery. Oct. 27: Works of Marshall, Sons & Co., Ltd., Gainsborough, Lincolnshire, for manufacture of engines, boilers and machines. Nov. 3: Works of John Fowler & Co., Ltd., Leeds, for manufacture of steam plows, road-transport and heavy-haulage engines, traction engines, etc.

The Wellman-Smith-Owen Engineering Works at Darlaston. Iron & Coal Trades Rev., vol. 103, no. 2798, Oct. 14, 1921, pp. 545–546, 18 figs. on pp. 547–550. Describes machine, fitting and erecting, and pattern shops, laboratory, welfare section, etc.

Layout. Building Machine Tools in a New Plant, F. L. Prentiss. Iron Age, vol. 108, no. 17, Oct. 27, 1921, pp. 1070–1075, 16 figs. Arrangement, transportation system, routing of material and lighting are features of Colburn Machine Tool Co., Cleveland, Ohio.

Factory Lay-out as an Aid in Reducing Costs. Machy. (N. Y.), vol. 28, no. 3, Nov. 1921, pp. 182–185, 8 figs. Describes new plant of Colburn Machine Tool Co., Cleveland, Ohio, laid out with view to economy in manufacturing.

A Machine Tool Shop of Unusual Construction, Fred H. Colvin. Am. Mach., vol. 55, no. 17, Oct. 27, 1921, pp. 668–670, 8 figs. Description of Colburn Machine Tool Co., Cleveland, Ohio.

Steam Turbine. New Works of the Compagnie Électro-Mécanique at Bourget (Seine) [La nouvelle usine de la Cie. Électro-Mécanique au Bourget (Seine)], Ch. Dantin. Le Génie Civil, vol. 78, no. 26, June 25, 1921, pp. 541–545, 8 figs. Describes constructional details of works, all reinforced concrete.

MACHINE-TOOL INDUSTRY

Orient as Market. The Orient As a Machine-Tool Market, W. H. Rastall. Am. Mach., vol. 55, no. 18, Nov. 3, 1921, pp. 730–5. Data on pre-war growth of foreign business and growth since 1913; foreign markets other than European. How to sell machinery in Asia. Address before Machine Tool Builders.

MACHINERY

Dismantling. Valuable Hints on the Dismantling of Machinery. Can. Machy., vol. 26, no. 15, Oct. 13, 1921, pp. 29–32, 8 figs. Discusses separation of rusted parts, seized parts, forcing methods, and bolt action.

Perforated-Record Control. The Control of Machines by Perforated Records, Emanuel Scheyer. Am. Mach., vol. 55, no. 19, Nov. 10, 1921, pp. 743–747, 8 figs. Principles of pneumatic and electric control of machinery. Difficulties of automatic control. Machines controlled by paper records.

Power Consumption. Determination of the Power Consumption of Machinery (Bestimmung des Kraftbedarfes von Arbeitsmaschinen). Elektrotechnischer Anzeiger, vol. 38, nos. 149, 150, 151, 152 and 153. Sept. 20, 21, 24 and 27, 1921,. pp. 1065–1066, 1073–1074, 1079–1080, 1087–1088 and 1095–1096. 11 figs. Notes on numerical determination of power consumption; determination by comparison with machines of same construction type, but different output; determination through measurement.

MANGANESE STEEL

Castings, Grinding. Grinding Manganese Steel Castings, F. B. Jacobs. Foundry, vol. 49, no. 19, Oct. 1, 1921, pp. 767–770, 8 figs. Frogs and switches produced from accurate patterns and carefully molded. Ground because too hard to machine. Annealed before grinding. Wheels are coarse grit in hard grades.

MARINE STEAM TURBINES

S.S. Giulio Cesare. The Machinery of the Four-Screw Geared Turbine S.S. "Giulio Cesare." Engineering, vol. 112, no. 2915, Nov. 11, 1921, pp. 662–664, 18 figs. partly on supp. plate and p. 666. Constructed by Wallsend Slipway and Eng. Co. Ltd.

MATERIALS

Testing. Testing Materials. T. W. MacAlpine. Eng. & Indus. Management, vol. 6, no. 18, Nov. 3, 1921, pp. 498–499. Plea is advanced for formation of a British national testing organization.

MEASURING MACHINES

Internal Diameters. A Machine for the Measurement of Internal Diameters, G. A. Tomlinson. Engineering, vol. 112, no. 2912, Oct. 21, 1921, pp. 558–560, 6 figs. Describes method and machine developed at Nat. Physical Laboratory, Teddington, England, which is said to give high accuracy and allow inside diameter to be explored to any extent necessary.

METALLOGRAPHY

Foundries. Applications of Metallography in Iron, Steel and Malleable Foundries (Anwendungen der Metallographie in der Eisen-, Stahl- und Tempergiesserei), Rudolf Stotz. Giesserei-Zeitung, vol. 18, nos. 24, 25 and 27, Sept. 20, 27 and Oct. 11; 1921, pp. 325–328, 341–344 and 370–372, 43 figs. Notes on microscopic investigation of iron castings. Paper read before Assn. German Foundrymen.

Microscopic Examinations. Metallography—The Microscopic Study of the Structure of Metals, Henry S. Rawdon. Am. Mach., vol. 55, no. 17, Oct. 27, 1921, pp. 659–664, 29 figs. Value of metallurgical science in industry; uses of the microscope. Study of metallic structures. Results of microscopic examinations.

Optics of. The Optics of Metallography, W. I. Patterson. Trans. Am. Soc. for Steel Treating, vol. 2, no. 2, Nov. 1921, pp. 108–132, 36 figs. Deals with important optical parts of microscopes.

METALS

Cold Work, Effect of. Strengthening Metals by Cold-Work, E. Heyn. Chem. & Met. Eng., vol. 25, no. 16, Oct. 19, 1921, pp. 735–736, 2 figs. Explains nature of changes in cold worked metal, elastic and plastic deformation, etc. From Metall und Erz, 1918, Nos. 22 and 23.

Protective Coatings. Metal Coatings as Protection Against Corrosion (Metalüberzüge als Rostschutzmittel), Werner Lange. Zeit. für Metallkunde, vol. 13, no. 9, June 1921, pp. 267–275, 36 figs. Discusses protective coatings of lead, tin and aluminum.

Refinement Tests. Refinement Tests with German Metals (Veredelungsversuche mit inländischen Metallen), H. Hanszel. Zeit. für Metallkunde, vol. 13, no. 10, July 1921, pp. 319–329, 1 fig. Deals with aluminum, mild steel, cast iron and electron, and discusses methods for testing of metals and alloys.

Rolling. Metal Rolling (Le Laminage), Sigma. La Métallurgie, vol. 53, no. 40, Oct. 6, 1921, pp. 1884–1887. Discusses longitudinal or parrallel rolling; cross or circular rolling, i.e., reeling; and helicoidal or oblique rolling, as for Mannesmann tubes.

Structural Properties. Structural Properties of Metals and Alloys, R. W. Woodward. Am. Mach.; vol. 55, nos. 15 and 16, Oct. 13 and 20, 1921, pp. 596–599 and 636–638, 2 figs. Applicability of metals; factors of strength and elasticity; compression; ductile and brittle materials; fatigue; thermal, magnetic and optical properties; corrosion.

METRIC SYSTEM

Arguments Pro and Con. The Metric System of Weights and Measures, David A. Molitor. Jl. Eng. Inst. Can., vol. 4, no. 11, Nov. 1921, pp. 569–572. Advantages of system, legal problems, transition steps.

Metric versus English System. Eng. & Contracting, vol. 56, no. 18, Nov. 2, 1921, pp. 426–427. Summarizes points in favor and opposed to metric bill. Reprinted from Lefax.

MILLING CUTTERS

Formed. Formed Milling Cutters, George H. Strain. Machinery (Lond.), vol. 19, no. 474, Oct. 27, 1921, pp. 109–112, 18 figs. Factors in design which eliminate waste of driving power; cutting angles, rake and clearance of circular tools; standards for convex and concave formed milling cuttings.

MILLING MACHINES

Heavy Vertical. Investigation of a Heavy Vertical Milling Machine (Untersuchung einer schweren Senkrechtfräsmaschine), Willi Mitan. Zeit. des Vereines deutscher Ingenieure, vol. 65, no. 43, Oct. 22, 1921, pp. 1116–1118, 13 figs. Construction and operation of new machine by Fritz Werner Corp. Berlin-Marienfelde, for unwieldy workpieces. Calculation of feeds and speeds. Performance tests.

Rotary. Reducing Costs by Rotary Milling. Machy. (N. Y.), vol. 28, no. 3, Nov. 1921, pp. 202–205, 10 figs. Examples of work advantageously handled on Becker vertical rotary milling machines.

MOLDING MACHINES

Modern. Modern Molding Machines (Neuere Form maschinen), U. Lohse. Giesserei-Zeitung, vol. 18, nos. 23, 24 and 25, Sept. 13, 20 and 27, 1921, pp. 308–311, 331–335 and 344–348, 20 figs. Construction development during recent years. Deals with hand and power-molding machines, pattern machines with lifting carriage, stripping-plate and roll-over machines, etc.

MONEL METAL

Welding. Monel Metal Welding, Michael Dzamba. Welding Engr., vol. 6, no. 10, Oct. 1921, pp. 41–42. Discusses welding generally, also welding of rods, sheets and castings, and soldering.

MOTOR PLOWS

Engines. The 45-60-Hp. B.M.W. Motor-Plow Engine (Der 45-60 B.M.W. Pflugmotor), Otto Schwager. Oel- u. Gasmaschine, vol. 18, nos. 6 and 10, June and Oct., 1921, pp. 97–104 and 164–165, 7 figs. Details of engine built by the Bavarian Motor Works Corp., Munich, based on their experiences in construction of aeroplane engines. Test results with described engine.

MOTOR TRUCKS

Future. The Motor Truck of the Future, Rolin W. Hutchinson. Indus. Management, vol. 62, no. 5, Nov. 1921, pp. 257–261, 4 figs. What permanent highways, pneumatic tires and ferro-steel will do in revolutionizing motor-truck engineering.

German. German Motor Trucks and Tractors (Der Kraftwagen als Nutzfahrzeug). Allgemeine Automobil-Zeitung, vol. 22, nos. 29, 30 and 31, July 16, 23 and 30, 1921, pp. 23–26, 26–30 and 21–26, 32 figs. Details of various types, including delivery trucks, tippers, timber-hauling trucks, hearses, street sprinklers, hook-and-ladder cars, omnibuses, etc.

N

NICKEL ALLOYS

Nickel-Aluminum-Copper. The Properties of Some Nickel-Aluminium-Copper Alloys, A. A. Read and R. H. Greaves. Metal Industry (Lond.), vol. 19, no. 13, Sept. 23, 1921, pp. 232–239, 23 figs. Discusses preparation; rolling and machining; tensile tests; properties of cast, cold-rolled and heat-treated alloys, etc. Paper read before Inst. of Metals.

NICKEL METALLURGY

Rolling. Rolling Pure Nickel, A. E. Surface. Sci. Am., vol. 125-A, no. 17, Nov. 1921, p. 34, 3 figs. Describes rolling of 99-per cent pure nickel into the various shapes into which mild steel is rolled, according to method developed by Charles T. Hennig and carried out at plant at Hyde, Pa.

NUTS

Acme Thread. Making an Accurate Acme Thread Nut, B. M. W. Hanson. Machy. (N. Y.), vol. 28, no. 3, Nov. 1921, pp. 197–199, 4 figs. Notes on difficulty of obtaining proper contact between screw and nut; use of roughing and finishing taps; lubrication when tapping; holding an Acme tap in a turret lathe.

O

OIL ENGINES

Marine. Oil Fuel Burning Installation on S.S. "Paris" (Installation de la chauffe au pétrole sur le paquebot "Paris"). Bulletin Technique du Bureau Véritas, vol. 3, no. 8, August 1921, pp. 181–185, 4 figs. (In English on pp. 186–188.) Discusses storage, piping, pumps, burners and operation, and gives test data.

Still. The Still Engine. Mar. Engr. & Naval Architect, vol. 44, no. 528, Sept. 1921, pp. 36–40, 4 figs. Describes engine which may be two-stroke or four-stroke type; burns gas, petrol or oil. Advantages, starting, overload, efficiency, etc.

OIL FUEL

Burning. The Burning of Oil Fuel, A. Keens. Mar. Engr. & Naval Architect, vol. 44, no. 529, October 1921, pp. 76–85, 12 figs. Discusses various types of machinery and its arrangement for burning oil fuel. Observations and comments derived from experience.

Combustion. Combustion of Fuel Oil, Percival J. Woolf. Iron & Coal Trades Rev., vol. 103, no. 2797, Oct. 7, 1921, p. 504. Discusses drawbacks of excess of air supplied for rapid combustion, advantages and disadvantages of an additional combustion chamber, and the Sklovsky patent for eliminating excess air. Extract of paper read before Refractory Matls. Section of Ceramic Society.

Handling. Security in Handling Inflammable Liquids Chem. Age (Lond.), vol. 5, no. 119, Sept. 24, 1921, pp. 372–373, 1 fig. Describes Mauclère patent for storage and protection of petrol which also permits distribution either in a continuous flow or in predetermined quantities.

Mexican. The Production and Combustion of Mexican Fuel Oil—VII, J. M. Pettingell and J. R. Carlson. Combustion, vol. 5, no. 5, Nov. 1921, pp. 209–212, 7 figs. Describes use of Mexican oil in various metallurgical furnaces, although sulphur content is high.

Power Uses. The Application of Oil to Power Purposes, Sydney H. North. Trans. Inst. Mar. Engrs., vol. 33, Sept. 1921, pp. 325–331. Shows increase in water evaporated per lb. of oil, and in thermal efficiency of Diesel engines.

OIL STORAGE

Shipyard Plant. Shipyard Bulk Storage Oil and

Paint Plant. Engineering, vol. 112, no. 2914, Nov. 4, 1921, p. 632, 10 figs. partly on p. 634. Describes installation at new yard of Furness Shipbuilding Co., designed with steel storage tanks and automatic measuring pumps for distribution of oils, layout being such as to reduce cost and increase ease of handling.

OILS

Linseed. Air Required in Baking Cores Made With Linseed Oil, A. A. Grubb and U. S. Jamison. Chem. & Met. Eng., vol. 25, no. 17, Oct. 26, 1921, pp. 793–795. Results of laboratory and plant experiments on consumption of air and oxygen in baking linseed oil-bound cores, together with a review of available data on absorption of oxygen by linseed oil in drying.

P

PARACHUTES

Aeronautical Life Belts. Parachutes. T. Orde Lees. Aviation, vol. 11, nos. 16 and 17, Oct. 17 and 24, 1921, pp. 451–453 and 485–488, 5 figs. Discusses parachutes in the sense of aeronautical life-belts, for pilots and passengers. Lecture before Roy. Aeronautical Soc.

PETROLEUM

Catalytic Oxidation. The Catalytic Oxidation of Petroleum Oils. C. E. Waters. Jl. Indus. & Eng. Chem., vol. 13, no. 10, Oct. 1921, pp. 901–903. Discusses briefly relation between oxidation of petroleum oils and formation of deposits in internal-combustion engines to sludging of transformer oils and to deterioration of turbine oils.

PIPE, CAST-IRON

Manufacture. Cast-Iron Pipe. The Method of Manufacture and Its Inspection. William R. Conrad. N. E. Water Works Assn., vol. 35, no. 3, Sept. 1921, pp. 205–220 and (discussion) pp. 220–227, 6 figs. Discusses manufacturing details, including drying, pouring, cleaning and testing.

Standardized. Standardized Cast Iron Pipes. Eng. Production, vol. 3, no. 56, Oct. 27, 1921, pp. 401–404, 10 figs. Describes methods of Stanton Ironworks Co., Ltd., Nottingham, England, as example of advantages attendant on standardization of foundry products.

PIPE, STEEL

Butt-Welded. Recent Improvements in the Manufacture of Welded Pipe. F. N. Speller. Blast Furnace & Steel Plant, vol. 9, no. 10, Oct. 1921, pp. 580–582. While there have been many improvements in appliances for butt-welding pipe since introduction of this process, the method of finishing has not been materially changed for some time.

Hammer-Welded. A Hammer-Welded Steel Pipe. Iron Age, vol. 108, no. 18, Nov. 3, 1921, pp. 1130–1131, 3 figs.; also Iron Trade Rev., vol. 69, no. 18, Nov. 3, 1921, pp. 1148–1151, 7 figs. Product of National Tube Co., Pittsburgh. Steel plates are bent to required shape and overlapping edges are heated and welded under hammer. Hammer-weld process adapted to large sizes of pipe. Protective coating applied.

Hammer-Welded Pipe: Its Manufacture and Use. Eng. & Contracting, vol. 56, no. 19, Nov. 9, 1921, p. 445, 1 fig. Notes on sizes and thickness; manufacturing process; physical properties of material; joints; elements of economy and efficiency. Describes a hammer-weld gas line. (Abstract.) National Bul. No. 13 published by Nat. Tube Co.

Manufacture. Bessemer Plant of Steel & Tube Company. Gilbert L. Lacher. Iron Age, vol. 108, no. 19, Nov. 10, 1921, pp. 1199–1205, 11 figs. Latest developments in design and equipment embodied in addition to Mark works, Chicago, for manufacture of pipe.

PISTONS

Aluminum, Machining. Precision Machine Work in the Production of Aluminum Pistons. L. Edward Schipper. Automotive Industries, vol. 45, no. 15, Oct. 13, 1921, pp. 722–725, 15 figs. Methods employed in manufacturing pistons for Essex engine. Special care exercised in machining piston pin hole square with piston axis, and in aligning piston with cylinder bore.

Machining. Machining Hudson Super-Six Pistons. Machy. (N. Y.), vol. 28, no. 3, Nov. 1921, pp. 225–227, 5 figs. Methods used by Hudson Motor Car Co. in producing pistons with high-production machinery at low cost.

PLATES

Perforated, Stresses in. Increased Stress Caused by Circular Holes in a Plate Under Tension (Ueber die Spannungserhöhung durch kreisförmige Löcher in einem gezogenen Bleche). Th. Pöschl. Zeit. für angewandte Mathematik u. Mechanik, vol. 1, no. 3, June 1921, pp. 174–180, 3 figs. Derivation of formulas for determining increase in stress caused by a number of holes, as for example, rivet holes in a plate.

POWER

Industrial, Analysis of. Analysis of Industrial Power. H. Goodwin. Power, vol. 54, no. 16, Oct. 18, 1921, pp. 584–588, 3 figs. Investigations based on latest census returns from North Atlantic States show more than 76,000 industrial plants, using in aggregate over 9,000,000 hp. of which over 2,000,000 hp. is supplied by steam engines, 600,000 by steam turbines, 540,000 by water power, 279,000 by internal-combustion engines, and remainder purchased power.

POWER GENERATION

Cost Systems. How to Follow Up Power Costs, N. A. Graigue. Indus. Management, vol. 62, no. 5, Nov. 1921, pp. 275–279, 3 figs. Analysis and distribution of operating costs to consumers.

Fuel Economy. Fuel Economy by the Adoption of Scientific Management in Power Generation and Utilization. David Brownlie. Eng. & Indus. Management, vol. 6, no. 14, 15 and 16, Oct. 6, 13 and 20, 1921, pp. 393–394 and 396, 421–424 and 433–436, 13 figs. Notes on flue-gas analysis and boiler feedwater meters.

POWER PLANTS

Coal Mine. Mixed-Pressure Turbine Installation with Regenerator Appreciably Decreases Power Costs at Nokomis, C. W. Smith. Coal Age, vol. 20, no. 19, Nov. 10, 1921, pp. 754–757, 7 figs. Describes very modern coal-mine power plant at Nokomis mine, Illinois, of Nokomis Coal Co.; capacity 1,300 kw. of which 1,000 kw. is mixed-pressure and 300 kw. high-pressure turbine power.

Design. Developments in Power Station Design—XII, XIII and XIV. Engineer, vol. 132, nos. 3432, 3433 and 3435, Oct. 7, 14 and 28, 1921, pp. 364–365, 390–392 and 445–447, 14 figs. Oct. 7: Babcock boilers for utilization of waste heat from coke ovens and blast furnaces. Oct. 14: Halberg-Beth blast-furnace-gas-cleaning plant; Kirke waste-heat boiler with integral economizer; and waste-heat boilers with vertical tubes. Oct. 28: Describes Bonecourt gas-fired boiler unit; Thomson boilers operated with coke-oven gas; Brett drop-forging-furnace waste-heat unit; Babcock & Wilcox furnace for burning saw-mill refuse.

Mine-Mouth. Seward Plant of Penn Public Service Corporation. Power Plant Eng., vol. 25, no. 19, Oct. 1, 1921, pp. 947–947, 17 figs. A mine-mouth power plant supplying industries in Johnstown district. Details of equipment, mechanical and electrical.

Modern Practice. Refinements of Practice in Modern Power Plants. I. L. Kentish-Rankin. Power Plant Eng., vol. 25, no. 20, Oct. 15, 1921, pp. 988–990. Discusses features regarding furnace construction and the overcoming of difficulties with superheater operation.

Superpower. The Performance and Cost of the Superpower System. Arthur R. Wellwood. Power, vol. 54, no. 19, Nov. 8, 1921, pp. 725–730, 10 figs. As result of work of Superpower Survey, certain vital facts concerning performance and cost of superpower system are presented, and conclusions drawn.

POWER TRANSMISSION

Machine Shops. Transmission of Power in Machine Shops. F. A. Pike. Mech. World, vol. 70, no. 1815, Oct. 14, 1921, p. 298, 3 figs. Advocates more direct driving.

PRESSES

Automobile Parts. Presses and Dies used in the Production of Motor-car Body Parts. Machinery (Lond.), vol. 19, no. 475, Nov. 3, 1921, pp. 117–121, 10 figs. Description of tools and machines used by Austin Motor Co., Ltd., Longbridge Works, Birmingham.

PRICES

Stop-Loss, Finding. Finding the "Stop Loss" Price Point. H. R. Boston. Indus. Management, vol. 62, no. 5, Nov. 1921, pp. 266–268. Definite way of estimating how far a price may be cut.

PRODUCER GAS

Qualitative Regulation. Device for the Qualitative Regulation of Producer Gas (Vorrichtung zur qualitativen Regelung von Generatorgas). Robert Nitzschmann. Feuerungstechnik, vol. 9, no. 22, Aug. 15, 1921, pp. 209–211, 2 figs. Discusses basic principles for qualitative regulation and describes arrangement which is said to fulfill required conditions.

PULVERIZED COAL

Advantages and Disadvantages. Firing With Pulverized Coal (Le Chauffage au charbone pulvérisé). P. Frion. Memoirs et Compte Rendu des Travaux de la Société des Ingenieures Civils de France, vol. 74, no. 4–5–6, April–June 1921, pp. 123–172. Report of Commission of Fuel Utilization, appointed by Minister of Pub. Works. Discusses actual developments in use of pulverized coal. Describes installation using it, its advantages and possibilities, and its inconveniences and dangers. See also Révue Universelle des Mines, vol. 11, no. 1, Oct. 1, 1921, pp. 48–56.

Firing With Pulverized Coal (Le Chauffage au charbon pulverisé), Sigma. La Métallurgie, vol. 53, no. 38, Sept. 22, 1921, pp. 1781–1782. Discusses disadvantages and draws conclusions comparing these with advantages. (Concluded.)

Boiler Firing. Burning Powdered Coal and Blast-Furnace Gas at River Rouge, Thomas Wilson. Power, vol. 54, no. 18, Nov. 1, 1921, pp. 664–670, 9 figs. Arrangement and construction of big boilers and their control. Pulverized-coal equipment and layout of gas piping and burners. Performance guarantees and operating force required.

Burning Powdered Coal in Boiler Furnaces, K. Kita. Jl. Inst. Elec. Engrs. of Japan (Denki Gakkwai Zasshi), no. 399, Oct. 1921, pp. 713–740. Author tries to make comparison of combustion of powdered coal with that of ordinary method, and points out important factors to be considered in construction of furnace. Bibliography. (In Japanese.)

PUMPING

Centrifugal and Air-Lift. Modern Pumping. Colliery Guardian, vol. 122, no. 3170, Sept. 30, 1921, pp. 933–934. Paper on "Modern High Speed Centrifugal Pumps" by S. F. Barclay and paper on Experiments in Air Lift Pumping by J. S. Owens. Read before British Assn. See also Eng. & Indus. Management, vol. 6, no. 18, Nov. 3, 1921, pp. 503–506.

PUMPS, CENTRIFUGAL

Design and Application. The Centrifugal Pump. S. F. Barclay. Engineering, vol. 112, no. 2914, Nov. 4, 1921, pp. 642–644, 8 figs. Notes on mechanical design and application. (Abstract.) Paper read before British Assn.

Manufacture. Manufacturing Centrifugal Pumps. Western Machy. World, vol. 12, no. 10, Oct. 1921, pp. 392–395, 12 figs. Describes machine operations on pump bases, brackets, spiral bodies, impellers, etc.

PUNCHING MACHINES

Efficiency. Increasing the Efficiency of Punching Machines (Zur Frage der Leistungssteigerung bei Lochwerken). Hugo Becker. Betrieb, vol. 3, no. 25, Sept. 15, 1921, pp. 832–838, 16 figs. Comparison of costs of punching work in the plating of a freight steamer with use of a simple punching machine and of a roller table machine shows economy of latter.

R

RADIOMETALLOGRAPHY

Possibilities. X-Ray Photography and Material Testing (Röntgenphotographie und Materialprüfung). R. Schenck. Stahl u. Eisen, vol. 41, no. 41, Oct. 13, 1921, pp. 1441–1449, 24 figs. Discusses nature of Röntgen rays and possibilities for their use in material testing and metallography.

RAILS

Magnetic Surveys. Magnetic Surveys of Railroad Rails. Iron Age, vol. 108, no. 20, Nov. 17, 1921, pp. 1271–1273, 7 figs. Determination of fissures obscured by heavy damage from gagging presses. Improvements being made in section and in straightening.

Second-Hand, Use of. Classification and Distribution of Second Hand Rail for Use in Track. Eng. & Contracting, vol. 56, no. 20, Nov. 16, 1921, pp. 463–464. Notes on supply and demand for used rail; variables to be considered in use of rail; recommended method of assigning and distributing rail.

RAILWAY CONSTRUCTION

Germany. Construction of the Railway Between Tongres and Aix-la-Chapelle (Der Eisenbahnbau Tongern-Aachen). E. Hunerwadel. Schweizerische Bauzeitung, vol. 78, nos. 14, 15 and 17, Oct. 1, 8 and 22, 1921, pp. 163–167, 182–184 and 201–205, 22 figs. Describes section including bridges and tunnels built by Germany between years of 1915 and 1918, said to be one of largest and most important works of engineering carried out during war.

RAILWAY ELECTRIFICATION

Austria. The Electrification of the Austrian Federal Railway (Die Elektrisierung der österreichischen Bundesbahnen). H. Baecker. Glasers Annalen, vol. 89, no. 5, Sept. 1, 1921, pp. 48–51, 1 fig. Notes on projects, hydroelectric and power-transmission plants.

Brazil. The Paulista Railway Electrification. S. B. Cooper. Ry. Rev., vol. 69, no. 16, Oct. 15, 1921, pp. 507–509, 8 figs. Describes Westinghouse equipment recently delivered and conditions making electrification desirable.

Heavy Traction. Electrification Report of the A.E.R.A. Ry. Elec. Engr., vol. 12, no. 10, Oct. 1921, pp. 391–396, 1 fig. Report of Committee of the Am. Elec. Ry. Assn. on heavy electric traction. Compares locomotives and multiple unit-cars. (Abstract.)

Italy. Economic Aspects of Electric Traction in Italy (Aspetti economici della trazione elettrica in Italia). Pietro Lanino. Ingegneria Italiana, vol. 7, no. 170, Sept. 10, 1921, pp. 144–146. Summarizes needs of Italian electrification and gives list of impending constructions.

Electrification Progress on Italian Railways. Giovanni B. Santi. Ry. Elec. Engr., vol. 12, no. 10, Oct. 1921, pp. 371–375, 6 figs. Discusses development of electrification on account of high price of coal and no oil resources. The Valtelline three-phase, 15-cycle, 3000-volt system has been working for 20 years.

Steel Plant. Electrification of the Steel Plant Railroad. R. B. Gerhardt. Blast Furnace & Steel Plant, vol. 9, no. 10, Oct. 1921, pp. 613–617. Discusses savings effected in fuel, repairs, labor, and depreciation; also discusses safety, frogs and switches, etc. (Abstract.) Paper read at Assn. Iron & Steel Elec. Engrs. Convention.

RAILWAY MOTOR CARS

Gasoline. Petrol Rail Motor Cars, Kalka-Simla Railway. Ry. Gaz., vol. 35, no. 15, Oct. 7, 1921, pp. 535–539, 7 figs. Describes car for narrow-gage mountain service in India under severe working conditions, due to steep inclines and many sharp curves. Design includes several noteworthy features particularly gearing and transmission, frame construction, and combination of coupled wheels and radial trucks to give flexibility on curves.

RAILWAY OPERATION

Automatic Train Control. Automatic Safety Apparatus and Automatic Train Control (Appareil automatique de sûreté et de contrôle des trains). Maurice Gouineau. Révue Générale de l'Élec-

tricité, vol. 10, no. 12, Sept. 24, 1921, pp. 406–412, 10 figs. Describes Regan system as adapted to French railroads.

Cab Signaling and Automatic Stopping of Trains (La répétition des signaux sur les machines et l'arrêt automatique des trains), J. Netter. La Technique Moderne, vol. 13, no. 3, March 1921, pp. 101–104, 7 figs. Criticism of Regan system recently tested on Paris-Dreux line; comparison with Rodolausse apparatus; systems used by principal French railroads.

Interchange of Rolling Stock. On the Question of Interchange of Rolling Stock, C. W. Crawford. Bulletin International Ry. Assn., vol. 3, no. 9, Sept. 1921, pp. 1275–1321. Discusses the question as it affects United States, Canada and Mexico. Gives summary of their regulations and practices, also answers to questions sent. Appendixes.

Passenger Traffic. Handling Heavy Passenger Traffic at Doncaster. Ry. Gaz., vol. 35, no. 14, Sept. 30, 1921, pp. 493–496 and 507, 4 figs. Describes the special traffic arrangements made by Great Central and Great Northern Railways in connection with the race traffic.

RAILWAY REPAIR SHOPS

Contract Shop, vs. The Cost of Contract vs. Railway Shop Repairs, J. W. Roberts. Ry. Age, vol. 71, no. 16, Oct. 15, 1921, pp. 729–731, 2 figs. Total cost to railroad was 28 per cent greater in its own shop than in a contract shop.

Experimental Scheme. An Experiment in Railroad Repair Work, Fred H. Colvin. Am. Mach., vol. 55, no. 20, Nov. 17, 1921, pp. 807–808. Securing greater interest by local management. Improved machinery and buildings. Describes scheme adopted by Erie R.R. at Hornell, N. Y.

Requirements. The Requirements for a Modern Car Repair Shop, H. H. Dickinson and Paul Schioler. Ry. Age, vol. 71, no. 19, Nov. 5, 1921, pp. 890–893, 3 figs. Type of building, character of tools and general plan for both steel and wood equipment.

RAILWAY SHOPS

American Practice. Railway Machine Shop Practice—III. Machinery (Lond.), vol. 19, no. 473, Oct. 20, 1921, pp. 67–69, 9 figs. Examples of American practice in machining bearing brasses, axle boxes and wedges.

Machine Tools for. Railway Shop Machine Tool Equipment. British Machine Tool Eng., vol. 1, no. 2, September-October 1921, pp. 277–399, 188 figs. A series of articles on railway-shop equipment, including locomotive boiler shop, wheel and axle shop, frame shop, spring shop, grinding shop, general machine shop, capstan and turret lathes, carriage and wagon frames, girder work, etc.

RAILWAY SIGNALING

Alternating-Current. Principles of Alternating Current Signaling, John S. Holliday. Ry. Signal Engr., vol. 14, no. 11, Nov. 1921, pp. 443–445, 9 figs. Explanation of motor and generator motion and transformer action that produces rotation in an induction motor.

Automatic. Road Test of New Automatic Train Control. Ry. Signal Engr., vol. 14, no. 11, Nov. 1921, pp. 431–432, 4 figs. Test conducted on system in which no physical contact is made between apparatus on locomotive and on roadway.

Automatic Block. Proposed Modification of Stop-and-Proceed Rule. Ry. Age, vol. 71, no. 19, Nov. 5, 1921, pp. 867–869, 4 figs. Details of practice on fourteen roads using "tonnage" signals, relaxing the stop-and-proceed rule. See also Ry. Signal Engr., vol. 14, no. 11, Nov. 1921, pp. 429–430.

Automatic Color Light. The Re-Signaling of the Liverpool Overhead Railway. Ry. Gaz., vol. 35, no. 16, Oct. 14, 1921, pp. 571 and 576, 4 figs., partly on p. 570. Describes automatic signaling system on electrically operated railroad, using color light signals only.

Block System. Absolute Permissive Block Signal System, C. A. Dunham. Ry. Signal Engr., vol. 14, no. 11, Nov. 1921, pp. 438–440, 7 figs. Study of single track signaling showing track layout and circuit diagram and explaining operation of trains between sidings. (Abstract.) Paper read before Kansas City Sectional Committee Meeting.

Electric. Principles of Alternating Current Signaling, John S. Holliday. Ry. Signal Engr., vol. 14, no. 10, Oct. 1921, pp. 389–390, 12 figs. Explaining an easy method of constructing vector diagrams and the application to track circuit problems.

Interlocking. Interlocking at a Railway Bridge in England, James Benjamin Ball. Ry. Signal Engr., vol. 14, no. 11, Nov. 1921, pp. 424–428, 7 figs. Interesting signaling features on Keadby Deviation Railway and movable span over Trent river. (Abstract.) Paper read before Inst. Civil Engrs.

One-Lever Route. One-Lever Route Signaling. Ry. Gaz., vol. 35, no. 18, Oct. 28, 1921, pp. 643–648, 9 figs. A new design of power locking frame whereby one lever is used to set up each route, signalman is given a visible indication of all that occurs, conflicting movements are rendered impossible and separate point levers are dispensed with entirely.

Progress, America. Progress of Railroad Signaling in America, H. S. Balliet. Ry. Signal Engr., vol. 14, no. 11, Nov. 1921, pp. 433–437. Detailed history of apparatus and methods used from the days of the smoke blanket to present efficient systems. Paper delivered before N. Y. Signal Sectional Committee.

Tunnel Signals. The Electric Signaling System in the Arlberg Tunnel (Zur Geschichte der elektrischen Fernmeldeeinrichtungen des Arlbergtunnels), L. Kohlfürst. Elektrotechnische Zeit., vol. 42, no. 34, Aug. 25, 1921, pp. 939–943. Describes numerous troubles experienced with system installed in 10.25-km. tunnel through which trains driven by steam locomotives are operated. A telephone cable, which when installed measured 8000 microhms resistance per km. from copper to lead sheath dropped in six years to only 0.2 microhm.

RAILWAY TRACK

Concrete Supports. Concrete Block Track Supports on Italian Railways. Eng. News-Rec., vol. 87, no. 17, Oct. 27, 1921, pp. 689–690, 2 figs. Fixed and rocking blocks placed longitudinally have rail seats at each end. Rockers insure vertical loading.

Maintenance. Distributing Expenditures in Track Maintenance, J. L. Starkie. Ry. Maintenance Engr., vol. 17, no. 11, Nov. 1921, pp. 403–405, 4 figs. Gulf, Colorado & Santa Fe is obtaining increased interest and efficiency by means of new work records.

Advantages of Budget System for Track Work, C. A. Morse. Eng. & Contracting, vol. 56, no. 16, Oct. 19, 1921, pp. 370–372. Points out that there should be a carefully prepared budget made up in fall of year including all probable expenditures of coming year outside of ordinary upkeep of track and roadbed. Apportioning amounts covered by budget. Paper presented before Roadmasters & Maintenance of Way Assn.

Scandinavian Construction. On the Question of the Construction of the Road-Bed and of the Track, K. Ahlberg. Bul. International Ry. Assn., vol. 3, no. 9, Sept. 1921, pp. 1147–1156. Concludes that Scandinavian countries will doubtless increase the load per locomotive axle considerably without changing maximum speeds. Appendix.

Turntables. Twin-Span Turntables on the Chesapeake & Ohio. Ry. Rev., vol. 69, no. 18, Oct. 29, 1921, pp. 563–568, 12 figs. Particulars of design and advantages to be realized in use of this type of turntable. Length 100 ft.; carrying capacity 450 tons; built by Bethlehem Bridge Corp.; used for heavy Mallet type of locomotives.

RAILWAYS

Consolidation. Consolidation of Railroads. Ry. Rev., vol. 69, no. 14, Oct. 1, 1921, pp. 423–437, 29 figs. Proposed consolidation of railroad properties of United States into a limited number of systems. Tentative plan of interstate commerce commision based upon Ripley report.

Shanghai-Nanking. Notes on the Shanghai-Nanking Railway. Ry. Gaz., vol. 35, no. 18, Oct. 28, 1921, pp. 637–638, 3 figs. Describes general characteristics, standard gage, high-capacity rolling stock, train control, train service, buildings, etc.

REFRACTORIES

Fireclays. Effect of Impurities in Fire Clays, C. E. Bales. Brick & Clay Rec., vol. 59, no. 10, Nov. 15, 1921, pp. 723–725. Points out that high-grade fireclays must be akin to kaolin. Explains coloration processes and neutralizing of harmful ingredients.

Furnace Lining. Carborundum Linings for Brass Furnaces, M. L. Hartmann. Can. Foundryman, vol. 12, no. 10, Oct. 1921, pp. 34–35. Explains how carborundum refractories are applied to problems in crucible, tilting or rotary, and reverberatory furnaces, with records of certain installations. Paper read at Foundrymen's Convention.

RIVETED JOINTS

Efficiency. A Criticism of High Efficiency Riveted Joints, John S. Watts. Boiler Maker, vol. 21, no. 10, Oct. 1921, pp. 278–279, 3 figs. Calculations indicate that use of multiple riveted joints does not increase seam efficiencies.

ROLLING MILLS

Bar Mills for Alloy Steel. Adapts Bar Mills to Alloy Steel, J. D. Knox. Iron Trade Rev., vol. 69, no. 20, Nov. 17, 1921, pp. 1275–1281, 12 figs. New 12 and 18-in. merchant units installed by Ohio steelmaker rounds out rolling equipment. Unique guide box prevents scrap loss. Rolls adjusted by set screws. Description of mills.

Chambéry, France. Rolling Mill and Foundry of the Société l'Aluminium Francais at Chambéry (Ateliers de laminage et de fonderie de la Société l'Aluminium français à Chambéry), Marcel Blondin. Révue Générale de l'Électricité, vol. 10, no. 12, Sept. 24, 1921, pp. 401–405, 5 figs. Describes equipment.

Electrically Driven. Some Methods of Obtaining Adjustable Speed With Electrically Driven Mills. K. A. Pauly. Proc. Engrs.' Soc. of Western Pa., vol. 37, no. 3, April 1921, pp. 158–178 and (discussion) 179–188, 19 figs. Discusses rolling mill practice, speed of rolling and systems of speed control.

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SCIENTIFIC MANAGEMENT

See INDUSTRIAL MANAGEMENT.

SEMI-DIESEL ENGINES

Open-Crankcase. The Open-Fronted Surface Ignition Engine, F. G. Butt-Gow. Trans. Inst. Mar. Engrs., vol. 33, Sept. 1921, pp. 239–269 and (discussion) 270–279, 22 figs. Discusses closed and open engines and compares cost of manufacture, running, overhauling, lubrication, etc. Describes various types of open-crankcase engines.

SHAPERS

Toolroom Work. A New Shaping Machine. Eng. Production, vol. 3, no. 55, Oct. 20, 1921, p. 372, 3 figs. Describes machine introduced by The Butler Machine Tool Co., Ltd., Halifax, designed especially for toolroom work.

SOLDERS

Investigation. Metal Solders (Zur Kenntnis der Metallote), L. Sterner-Rainer. Zeit. für Metallkunde, vol. 13, no. 11, Aug. 1921, pp. 368–379, 6 figs. Deals with tin-lead, aluminum, binary copper-zinc, and silver solders, copper-zinc solders containing tin, and iron, steel and gold solders. Determination of composition, melting point, tensile strength and hardness, based on which valuation of the different solders is given.

SPRINGS

Coil. The Manufacture of Coil Springs, A. W. Allen. Machinery (Lond.), vol. 19, no. 474, Oct. 27, 1921, pp. 85–89, 17 figs. Coiling machines; open coil barrel springs; press operations; eye forming; cutting, eyeing and bowing.

Compression. Nested Steel Compression Springs, T. F. Stacy. Am. Mach., vol. 55, no. 20, Nov. 17, 1921, pp. 795–796, 2 figs. Deals with design of concentric springs so proportioned that all springs are worked to maximum fiber stress.

Design. The Design of Springs, Joseph Kaye Wood. Am. Mach., vol. 55, no. 17, Oct. 27, 1921, pp. 674–677, 10 figs. Control of the "spring criterion." Formulas for leaf springs constrained at one or both ends. Characteristics of coil, spiral and buffer springs.

A General Method for Spring Design, Joseph Kaye Wood. Am. Mach., vol. 55, no. 19, Nov. 10, 1921, pp. 757–762, 3 figs. Types of springs. Economy index and load-deflection rate. General formulas and table of constants. Parallel scale chart. Importance of material index.

STANDARDIZATION

Automobile Industry. Industrial Standardization, Geo. W. Watson. Automobile Engr., vol. 11, no. 155, Oct. 1921, pp. 356–358. Advocates more standardization in British automobile industry, including agricultural tractors, etc. Résumé of presidential address before Instn. of Automobile Engrs.

STEAM

Callendar Equations. The Callendar Equations for Steam, Gerald Stoney. Beama, vol. 9, no. 4, Oct. 1921, pp. 345–350, 3 figs. Abstract of some of the best and easiest ways in which to use these equations, with special reference to steam turbine practice.

Production and Distribution Accounting. Accounting for Steam Production and Distribution, A. R. Smith. Power, vol. 54, no. 17, Oct. 25, 1921, pp. 630–633, 1 fig. Describes two forms of balance sheets and enumerates possible losses which can be detected by their use. Ways and means and advantage of metering boiler outputs.

STEAM-ELECTRIC PLANTS

Diagrammatic Recording in. How Can the Executive Keep in Touch with Plant Economy? C. H. Delany. Jl. Electricity & Western Industry, vol. 47, no. 7, Oct. 1, 1921, pp. 267–268, 4 figs. Diagrammatic method of recording results in operation of a steam electric power plant.

STEAM ENGINES

Uniflow. A 200 hp. Uniflow Steam Engine. Power House, vol. 14, no. 18, Sept. 20, 1921, pp. 21–23, 4 figs. Built by Galloways Ltd., Manchester. Has a novel high-speed valve gear and compression release.

[See also LOCOMOBILES.]

STEAM METERS

Types. Modern Feedwater and Steam Meters (Neuere Speisewasser- und Dampfmesser), W. E. Germer. Zeit. für Dampfkesse. u. Maschinenbetrieb, vol. 44, no. 33, Aug. 19, 1921, pp. 259–261, 3 figs. Details of piston disk meter with cylindrical measuring disk; the Woltmann meter for turbine condensate; Venturi meter for water and steam.

STEAM PIPES

Reducing Resistances in. Economies Obtainable by Reducing Resistances in Steam Piping, O. Denecke. Mech. Eng., vol. 43, no. 11, Nov. 1921, pp. 735–738, 2 figs. Discussion of general principles on which design of steam piping in power plants should be based, with comparison of formulas suggested for various elements affecting steam consumption as function of resistances encountered to flow of steam. Translated from Zeit. fur Dampfkessel u. Maschinenbetrieb.

STEAM POWER PLANTS

Modern Design. Modern Steam Power Station Design, Frank S. Clark. Jl. Franklin Inst., vol. 192, no. 4, Oct. 1921, pp. 413–452, 11 figs. Notes on present status of turbine design; economical and mechanical features of station design; operation of plant.

STEAM TURBINES

Blading Failures. Low-Pressure Turbine Blading Failures in Destroyers, D. F. Ducey. Engineering, vol. 112, no. 2913 and 2914, Oct. 28 and Nov. 4, 1921, pp. 615–619 and 647–650, 15 figs. Results of chemical analysis of damaged blades, metallographic examination, various heat-treatment, impact-shear and bend tests carried out at experiment station. (Abstract.) Reprinted from Jl. Am. Soc. Nav. Engrs.

STEEL

Artificial Seasoning. Artificial Seasoning of Steels, H. J. French. Am. Mach., vol. 55, no. 19, Nov. 10, 1921, pp. 768–771. Review of available data on length changes and spontaneous generation of heat in hardened steels. Results of preliminary experiments on artificial seasoning. Printed by permission of Bur. of Standards.

Automobile Gear. Investigation of Tooth Wear

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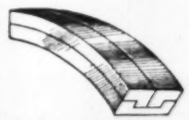

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